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Swedish Market Basket Survey 2015

– per capita-based analysis of nutrients and toxic compounds in market baskets and assessment of benefit or risk

Livsmedelsverket
National Food Agency

Preface

The present report presents results from the latest Swedish market basket study, in which food was sampled in 2015 (Market Basket 2015). The presented data give food levels and per capita intake estimations of a number of compounds, both nutrients and potentially toxic substances, with the aim to give a better knowledge base for two of the National Food Agency's (NFA) goals, i.e. healthy dietary habits and safe foods. This market basket study is the fourth in a series, and earlier surveys were performed 1999, 2005 and 2010, giving the opportunity to study time trends of the actual compounds.

We believe that the main target groups for reading and using the report are experts dealing with risk assessment and risk management at national or regional levels, working at agencies or institutes. Also other expert groups within the food sector should benefit from studying this report. However, the large data volumes and the textbook style of the report may not attract the general public, but the extended summary could in this case give a sufficient overview.

The method used to estimate per capita intakes are based on Swedish Board of Agriculture's food consumption statistics and this data is crucial for performing the subsequent estimations. Other important actors are colleagues purchasing the food stuff and treating samples at the lab, as well as organizing storage of food samples. The chemists have all made significant analytical efforts, and a number of authors representing various disciplines have made valuable contributions to this market basket report. All contributing colleagues, both within and outside NFA, are mentioned separately (see Contributors to the Report).

A special acknowledgement is given to the following experts for important review contributions of this Market Basket document: Marika Berglund (Institute of Environmental Medicine, Karolinska Institute), Britta Hedlund (Swedish Environmental Protection Agency, Stockholm), and Leif Busk and Irene Mattisson, (both NFA).

Finally, we would like to acknowledge the Swedish Environment Protection Agency for their generous financial support of chemical analyses of potentially toxic compounds in our food baskets.

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Content

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1	22 May 2017	
2	15 June 2017	11.1 - altered heading (Macronutrients); protein analysis included (Table 11.1:3); 11.2 – correction of vitamin E levels in beverages (Tables 11.2:1 and 11.2:2), in fish after cooking (Table 11.2:3), and corresponding corrections in text; 11.4 – general correction of metal intake from dairy prod. , use of median levels in calc. of Pb intake from dairy prod. (corr. of Tables 11.4:3 and 11.4:4, Figure 11.4:2, and in corresponding text); Reference list – minor changes, two references deleted (Pearson et al., 2013; Öhrvik et al., 2010)

1. Executive summary

The National Food Agency (NFA) has repeatedly conducted market basket (MB) studies, in which representative food samples from the Swedish market are analysed for nutrients and toxic compounds. By the use of food production and trade statistics, in combination with population statistics, per capita (populations mean) intakes of nutrients and chemicals from foods available on the Swedish market are estimated. One major aim of these studies is to obtain a systematic overview of average dietary intakes of nutrients and chemicals. The data can be used to estimate the Swedish population´s adherence to nutrient recommendations and the intake of potential toxic chemicals in relation to health-based guidance values. Moreover, MB studies identify food groups that are major sources of nutrient and chemical intake. Since NFA have conducted four MB studies since 1999 temporal trends of per capita nutrient and chemical intake can be studied. MB studies can also give a first look at the contamination situation for chemicals that recently have been identified as potentially problematic food contaminants.
The present study is based on food sampled during May-June 2015, thus the project name Market Basket 2015.

Overall conclusions

Taking into account the estimated per capita intakes of studied compounds in relation to recommended intake levels (nutrients) or adverse health-based reference levels (toxic compounds), and including time trend data when such are available, some overall conclusions could be made. Regarding the nutrient intake, a beneficial, decreasing trend on sodium and possibly also on added sugars was observed, although this study suggests that the estimated intakes of sodium and added sugar are still too high. The fat quality has improved, i.e.an increasing part consists of unsaturated fat. The per capita intakes of most minerals are in line with the Nordic Nutrition Recommendations (2012), but the exceptions are too low supplies of iodine and for women of childbearing age also iron. In case of iodine, the estimated intake has decreased markedly since the last MB study (2010). Furthermore, estimated intake of dietary fibre is lower than recommended (NNR, 2012).

Several potentially toxic, non-essential metals have estimated per capita intakes not very far from health-based tolerable intakes or other health-based reference points (RP). Among these are cadmium, inorganic arsenic, mercury and lead. In case of cadmium, the per capita intake is estimated to about half of the RP, which means that a certain part of the population (i.e. children, high consumers of cadmium-rich food items) will have an intake above this reference. In addition, MB data from 1999 and onwards show an increase in per capita cadmium intakes with time. The lead per capita intake is a little less than 20% of the RP (based on neurotoxic effects in children) - in this case no clear threshold for health effects is defined, but exposures below the RP are associated with a low risk. Among the organic contaminants, many compounds (e.g. PCB, chloropesticides, BFRs) show decreasing temporal trends and have per capita intakes sufficiently low compared to health-based reference points. A similar situation is seen for PFOS and PFOA, even if no decreasing time trend is seen for PFOA. However, the per capita intake

of dioxin-like compounds are still near RP, especially if the new US EPA reference intake is used, and a certain part of the population will have an intake of dioxin-like compounds above this reference. The studied compound groups with carcinogenic potentials, PAHs and 3-MCPD/glycidol, have low per capita intakes that do not constitute any apparent health concern. Finally, it should be remembered that exceeding of RPs does not directly result in adverse health effects, but rather that the margin of safety will be smaller.

In an attempt to make the risk assessment of the studied toxic compounds more comparable, a standardized method for risk characterization was applied (the Risk Thermometer). Comparsion of compounds across all groups in the present MB study (32 toxic compounds and two essential mineral elements) was performed, representing a risk-based ranking of chemical exposures at population/national level. Non-essential mineral elements and dixoin-like compounds were ranked the highest: risk class 3 (low-to-moderate concern). The exposures to remaining compound were regarded to be of no or low concern. The results obtained with the Risk Thermometer are more or less in line with the conclusions based on separate assessment of compounds in this study using ordinary risk assessment methods. Finally, it should be stressed that certain population groups may have intakes that strongly diverge from the population mean, due to body weight-based differences and special dietary habits, which may place them in another risk class than that determined by the per capita intake in this report. Also, additional exposure not covered in the MB study (e.g. drinking water) may change the risk classification.

Summary on specific food components and compounds

Fat and fat quality

Estimated average intakes of fat, monounsaturated fatty acids, trans-fatty acids (0.85-1 g per day), n-3 fatty acids, linoleic and alpha linolenic acid were in line with Nordic Nutrition Recommendations (NNR). However, for saturated and polyunsaturated fatty acids intakes were not in line with recommendations. In the current study, fat was calculated to provide on average about 38% of the energy intake (E%) compared to 34 E% in MB 2010. An increased contribution of fat from ‘sugar and sweets’, ‘dairy products’ and ‘fats and oils’ resulted mainly in an increased intake of monounsaturated fatty acids, estimated to 15 E%. Although the fat quality overall could be regarded as beneficial for health and in line with NNR, energy contribution from the high fat intake might make it difficult to maintain a healthy energy balance unless having an active lifestyle.

Carbohydrate and carbohydrate quality

Intake of dietary fibre was estimated to be about 2 g/MJ, which was higher than MB 2010 but still below the recommendation of 3 g/MJ. Also for added sugar the trend was positive from a health point-of-view, calculated intake decreased from 112 g per day in 2010 to 80-85 grams per day in the current MB study. However, estimated intake of added sugar of 11 E% is still above the recommendation of less than 10E%. With a high intake of sugar it might be difficult to have sufficient intakes of vitamins and minerals without having a too high energy intake.

Compared to previous MB study the pattern of sugars has changed, particularly intake of sucrose has decreased whereas intake of glucose and fructose has increased. This is possibly a consequence of use of other sweeteners than sucrose, e.g. high-fructose syrups.

Vitamins

Average estimated intakes of vitamin D_3 and folate were close to average requirement while the intake of vitamin E and vitamin K was higher. Pilot study shows that differences in vitamin data due to cooking should be considered.

Minerals and essential elements

For essential minerals estimated intakes were above NNR, except for iodine and for women in fertile ages also iron . Since 1999 estimated iodine intake has decreased by 50%, which is troublesome, even if intake of iodine is underestimated as household salt is not included in the MB study. The reduction is most prominent in important iodine sources such as 'fish', 'meat' and 'dairy products'. The European Food Safety Agency`s (EFSAs) opinion to reduce supplementation of iodine to feed for animals in food production might contribute to this observed decrease, but other aspects such as proportion of iodine antagonists (e.g. rape seed oil) in the animal feed most likely also play a role. Decreased use of marine feed components in aquaculture might be another explanation for the reduced content of iodine, and also of selenium, in fish. Furthermore, decreased use of iodised salt in food industry, as e.g. indicated by no iodine found in cured and processed meats, might contribute to the reduced iodine intake. For sodium a beneficial trend in estimated intake since 2010 was observed and the current intake was estimated to 3 g per day. However, despite underestimation in salt intake, as no household salt is included in the MB, intake was still above the recommendation (population target 2.4 g per day).

Non-essential elements

According to the present MB study, all of the studied toxic metal are below, or sometimes well below, their respective reference points. The metal with the smallest margin between estimated intake and its reference health value is cadmium (52% of TWI), and also for other metals these margins are relatively small. Because of the per capita method used some individuals in the population will most likely have cadmium intakes clearly above the TWI. We are also aware of that new adverse effect findings may lead to future adjustments of TWI. In addition, a suggested time trend increase in per capita intake of cadmium should be noted. Regarding arsenic, iAs is the main toxic arsenic species and data on iAs are needed and have indeed recently been produced. The per capita intake (MB 2010 + 2015 data) is below (17% of RP) the reference point for iAs. The two additional heavy metals, mercury and lead, have been studied in food for many years, without recognising any time trend. Even if their per capita intakes are below their reference points for health effect, consumers with certain habits (e.g. mercury: high fish intake) may have a considerably increased intake of these metals. Consequently, a further lowering of the intake of these heavy metals is desirable. In case of aluminium, the per capita intake is low in comparison to its health RP but other exposure sources except for food must be taken into consideration. Nickel and silver have low per capita intakes in relation to their health RPs. Finally, exceeding of health RPs does not directly result in adverse health effects, but rather that the margin of safety will be smaller (see also General discussion).

Persistent organic pollutants (POPs)

The estimated per capita intakes of sumDDT and HCB, two important members of the chlorinated pesticide group, are well below the health-based guideline intakes for these compounds. In addition, the mean per capita intakes of DDT compounds, HCB, chlordanes/nonachlor have decreased during the period 1999-2015. A similar situation is obvious regarding the brominated flame retardants (BFRs) PBDEs and HBCD - per capita intakes of BFRs are well below intakes stated as being of no health concern by EFSA, even when considering cumulative intake of the studied BFR mixture. The mean per capita intake of low/medium-brominated PBDEs was more than halved during the period 1999-2015. The estimated intake of deca-bromodiphenyl ether, BDE-209, is lower 2015 than 2010 but the decrease is not statistically significant. Furthermore, the per capita consumption of PCB-153, used as a marker for total PCBs, and PCDD/F/PCB ("dioxins") TEQs decreased with 4.5% per year between 1999 and 2015. When using a body weight of 76.6 kg the per capita intake of PCDD/F/PCB TEQ is 4-fold lower than the tolerable daily intake (TDI) established by the EU Scientific Committee on Food (SCF) in 2001 and 1.5-fold lower than the reference dose published by US EPA in 2012. When using body weight for children and adolescents the US EPA reference dose is exceeded.

Per capita intake of the highly fluorinated chemicals PFOS and PFOA is well below the health-based guideline intakes established by EFSA in 2008 and by US EPA in 2015. Note however that the intake from drinking water, which in certain cases could be of significant importance, is not included in the market basket calculation. Intake of PFOA did not change significantly during the study period, whereas the intake of PFHxA, PFOS and the PFOS-related compound PFOSA decreased between 1999 and 2015, with PFOSA showing the fastest decrease. Regarding the long-chain fluorinated carboxylic acids, they appeared to increase between 1999 and 2010 and then decrease between 2010 and 2015.

Two additional groups of POPs, chlorinated paraffins (CPs) and phosphorous flame retardants (PFRs) were for the first time included in the market basket studies because of their detection in environmental samples and a increased global industrial use. Both groups of chemicals were found in several food categories not only belonging to those from animal production. This distribution pattern differs from the well-known lipid-soluble environmental contaminants PCBs and dioxins, that are mainly found in foods containing animal fat. For CPs, using the lowest suggested TDI (6 µg/kg bw/day), the estimated per capita intake is lower by a factor of more than 100. In the case of PFRs, four of the studied compounds (TCEP, TPHP, TDCIPP and TCIPP) showed large margins between estimated intakes and to the corresponding health-based reference doses (15 000-80 000 ng/kg bw/day).

Mycotoxins

Regarding mycotoxins, the average exposures are generally low in the Swedish population according to the results of the present MB study, and below health-based reference values. Mycotoxins are very heterogeneously distributed in food commodities which make representative sampling difficult. Despite this fact, the exposure assessments from this MB study were in surprisingly good agreement with other estimates of average intake made by NFA or EFSA. As many data points were below LOQ, future MB studies need to improve the sensitivity of the analytical methods to give more reliable results.

PAHs and 3-MCPD/glycidol

Of the large group of PAHs the most studied compound is benzo(a)pyrene (BaP), and the main health concern is the carcinogenicity. Today there are established maximum levels for BaP and for the sum of BaP, Benz(a)anthracene, Benzo(b)fluoroanten and Chrysene (PAH4) in different foodstuffs. In comparison with the B(a)P and PAH4 levels in Sweden fifteen years ago, using about the same selection of food for analysis, the content as well as the estimated total intake has decreased. This decrease is neither due to more sensitive analythical methods, nor to an apparent change in consumption pattern, but to a lower PAH content in food. The lower PAH levels may be a result of improved production processes and probably also because of lower air pollution. The intake via food of BaP is estimated to about 30 ng/person a day and of PAH4 160 ng/person and day.

3-MCPD and glycidol are for the first time included in the basket market studies due to Commission recommendation on the monitoring of the presence of 3-MCPD and glycidyl fatty acid esters in food and EFSAs riskassessment. They are formed during heating of fat, as a reaction product of lipids and chloride, in fat-containing foods. From animal studies it is concluded that both 3-MCPD and glycidol are carcinogenic. 3-MCPD has a non genotoxic mechanism while glycidol is genotoxic. However, based on the mean concentrations in the collected MB food samples, the resulting per capita intake was about 26 and 8 µg/person and day for 3-MCPD and glycidol, respectively. These results suggest a low health risk concerning glycidol and 3-MCPD in Sweden.

Phenolic chemicals

Generally, man-made phenolic compounds have been found in comparably low concentrations in foods so far, but these levels are nevertheless important to monitor in order to follow their change over time and to predict the potential risks for human health. In the present study, analytical method development for phenolic chemicals was complicated and only a limited amount of results were produced. To improve the performance of quantitative analysis in future MB studies, the contribution effect of the contamination from the laboratory environment needs to be investigated and controlled to ensure the reliability of quantitative measurements.

Analyses of food categories, comparing as purchased with as ready-to-eat

Analysis of food groups from the pilot cooking study in which food items belonging to the four categories cereals, meat, fish, and potatoes were cooked as ‘ready-to-eat’, and compared to these groups analysed as purchased, resulted in slightly lower estimated intakes of fat and fatty acids after cooking, whereas no significant differences were found for essential minerals. The vitamin analyses revealed often somewhat higher intakes after cooking treatment; one hypothetical explanation could be that a more effective extraction of vitamins occurs if the food items are heated/cooked. Results from both the non-essential metal and the PCB/dioxin analyses revealed only small, if any, changes, and in both directions.In general, the pilot study did not show any major changes in intakes of the studied compounds compared to the uncooked alternative, and whether ready-to-eat processing of food items before sample preparation will add significantly to the study quality is not sufficiently well answered in this study.

2. Sammanfattning

Livsmedelsverket utför regelbundet s.k. matkorgsstudier, där representativa livsmedelsprover från den svenska marknaden analyseras avseende innehåll av både näringsämnen och toxiska ämnen. Med hjälp av Jordbruksverkets statistik över den svenska livsmedelskonsumtionen, grundad på produktions- och försäljningssiffror, erhålls per capita-konsumtionsdata (ett mått på hela populationens medelkonsumtion). Dessa konsumtionsvärden kombineras med analysdata av ämnens förekomst i livsmedel och vi erhåller då ett medelintag (per capita-intag) för de sökta ämnena. Med hjälp av dessa matkorgsgrundade per capita-intagsdata kan vi undersöka ”medelkonsumentens” intag av olika näringsämnen i förhållande till näringsrekommendationer och intaget av toxiska kemikalier jämfört med hälsobaserade referenspunkter. Eftersom matkorgsundersökningar har gjorts vid upprepade tillfällen sedan 1999 kan också tidtrender för intaget av näringsämnen och toxiska ämnen studeras. Matkorgsstudier kan även användas för att undersöka exponeringssituationen för ämnen som identifierats som nya problemkemikalier inom livsmedelsområdet. Den nu genomförda undersökningen grundar sig på livsmedelsprover insamlade under maj-juni 2015, därav projektnamnet Matkorgen 2015.

I Matkorgen 2015 har vi studerat ett antal näringsämnen, och grundat på resultatet från per capita-beräkningarna kan några övergripande slutsatser dras. En hälsobefrämjande nedgång av beräknat saltintag, och eventuellt även av tillsatt socker, kan observeras, fastän dessa intag fortfarande är för höga jämfört med nordiska näringsrekommendationer (NNR). Den näringsmässiga fettkvaliteten har också förbättras, dvs. en ökande andel av det totala fettet utgörs av omättade fettsyror. Tillgängligheten av de flesta mineralerna är i linje med NNR, förutom för jod samt, hos kvinnor i barnafödande ålder, även järn. När det gäller jod har det beräknade intag också sjunkit kraftigt jämför med den förra undersökningen (2010). Dessutom är det beräknade intaget av fibrer lägre än rekommenderat enligt NNR.

Ett flertal potentiella toxiska, icke-essentiella, metaller har analyserats i Matkorgen 2015, och i många fall ligger per capita-intaget inte så långt ifrån tolerabla intag (ex. TDI) eller motsvarande hälsomässiga referenspunkter (RP). En av dessa metaller är kadmium, och här är det beräknade intaget på ungefär halva TDI, vilket betyder att en viss del av populationen (främst barn och högkonsumenter av kadmiumrik föda) kommer att överskrida TDI. Dessutom tycks matkorgsdata från 1999 och framåt påvisa en viss ökning av per capita-intaget. I fråga om bly är det beräknade intaget ca 20% av RP (baserat på neurotox-effekter hos barn; ingen definitiv tröskelnivå funnen). Bland de organiska miljökontaminanterna uppvisar många ämnen (ex. PCB, dioxiner) sjunkande tidstrender och deras per capita-intag är hälsomässigt säkra jämfört med RP. En likande situation gäller för PFOS och PFOA (de enda högfluorerade PFAS-ämnena som hittills erhållit RP), även om PFOA-intaget inte ses sjunka med tiden. Intaget av dioxiner och dioxinlika PCBer är emellertid fortfarande nära hälsomässiga referenspunkter, speciellt om nya RP från USAs naturvårdsverk (US EPA) används som jämförelse, och en viss del av populationen kommer att ligga över denna RP. Det kan även noteras att per capita-intagen av ämnen som har carcinogena egenskaper, PAHer och 3-MCPD/glycidol, ligger förhållandsvis lågt och utgör inte någon uppenbar hälsorisk. Slutligen bör vi komma ihåg

att överskridanden av RPs inte behöver betyda att hälsoeffekter uppkommer, utan snarare att säkerhetsmarginalen krymper.

I syfte att göra riskbedömningen av studerade ämnen mer jämförbar användes en metod (Risktermometern) för att standardisera riskkaraktärisering, vilken är en del av riskbedömningen. Jämförelse mellan ämnen inom alla grupper i den aktuella matkorgsstudien (32 toxiska ämnen och två essentiella spårelement) genomfördes, vilken i detta fall innebär en riskrankning av kemisk exponering via livsmedel på nationell populationsnivå. Icke-essentiella mineralämnen (toxiska metaller) och dioxinlika ämnen fick den högsta rankningen i modellen: klass 3 (”måttlig risk”). Exponeringarna för de återstående ämnena pekar enligt samma modell på en låg eller obefintlig risk. Resultaten som erhålls med hjälp av risktermometermodellen ligger i stort i linje med de slutsatser som har förslagits för enskilda ämnen med ordinarie riskbedömningsmetoder. Det ska samtidigt understrykas att viss del av populationen kan ha intag av ämnen som starkt avviker från populationsmedelvärdet pga kroppsviktsbaserade skillnader eller speciella kostvanor, vilket kan placera dessa populationer i en annan riskklass än den som bestämts grundat på per capita-intagsdata i denna studie. Dessutom kan andra exponeringskällor än den som studerats här (ex via dricksvatten eller inandning) komma att förändra riskklassningen.

3. List of abbreviations

ADI	Acceptabel daily intake
BaP	Benzo(a)pyrene
BFRs	Brominated flame retardants
BMDL	Benchmark dose, lower confidence limit
CPs	Chlorinated paraffins
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DHA	Docosahexaenoic acid
DON	Deoxynivalenol
EFSA	European Food Safety Agency
EPA (1)	(US) Environment Protection Agency
EPA (2)	Eicosapentaenoic acid
FA	Fatty acid
GC	Gas chromatography
HBCD	Hexabromocyclododecane
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HPLC	High-performance liquid chromatography
IARC	International Agency for Research on Cancer
JECFA	Joint Expert Committee on Food Additives
JMPR	Joint Meeting on Pesticide Residues
LB	Lower bound
LOD	Limit of detection
LOQ	Limit of quantification
MB (1)	Market basket
MB (2)	Medium bound
3-MCPD	3-Monochloropropane-diol
MDL	Method detection limit
MOE	Margin of exposure
MUFA	Monounsaturated fatty acid
NFA	National Food Agency
NNR	Nordic nutritional recommendations (Nordiska näringsrek.)
NOAEL	No-observed-adverse-effect level
OTA	Ochratoxin A
PAHs	Polycyclic aromatic hydrocarbons
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls
PCDD/DFs	Polychlorinated dibenzo-p-dioxins and dibenzofurans
PFRs	Phosphorous flame retardant
PFASs	Per- and polyfluorinated alkyl substances
POPs	Persistent organic pollutants
PUFA	Polyunsaturated fatty acid
RP	Reference point
SBA	Swedish Board of Agriculture
SCF	Scientific Committee for Food

SFA	Saturated fatty acid
TDI/TWI	Tolerable daily/tolerable weekly intake
TDS	Total diet study
TEQ	Toxic equivalents
TFA	Trans fatty acid
UB	Upper bound
WHO	World Health Organization
ZEA	Zearalenon

4. Background and aims

The National Food Agency (NFA) regularly performs market basket (MB) studies which include analysis of levels of nutrients and toxic compounds in commonly purchased foods on the Swedish market. The MB studies also include quantitative estimations of the average exposure to these compounds in the Swedish population, using per capita estimations (i.e. the total weight of the specific food category, sold annually in Sweden, divided by the number of total inhabitants in the country). The MB studies have the advantage to produce considerable amounts of relevant data in a cost-effective way, including analytical data on compounds not covered in the NFA food composition database. A major limitation is that the exposure estimates refer to population means, which precludes studies of consumption/exposure differences. However, the MB studies could be supplemented by data from food consumption surveys and biomonitorings to give a more detailed picture regarding time trends and exposure among certain population groups and high consumers of various food categories.

The main aims for performing MB studies are

- to obtain exposure data for a variety of compounds in order to evaluate adherence to nutrient recommendations or possible adverse health consequences due to toxic compounds, when effect levels are known
- to assess contribution of major food categories to the total exposure. This data could be used in various management activities
- to evaluate time trends in the exposure to the studied compounds, as the MB approach has been performed in roughly the same way since 1999

In Sweden, MB studies were first performed 1987 and 1991 with focus on radioactivity (Cs-137) in food as a consequence of the Chernobyl accident in 1986 (Ohlander et al., 1991, Möre et al., 1995). In addition, these MB samples were also used for estimating exposure to minerals and metals (Becker and Kumpulainen, 1991) and dioxins (internal report). From 1999, MB studies have been conducted roughly every five years using a similar protocol, making it possible to compare data and to investigate time trends. Results from the 1999 MB study have been presented on POPs (Darnerud et al., 2006) and minerals and metals (Becker et al., 2011), and data from 2005 have been presented regarding POPs (Törnkvist et al., 2011) and nutrients, e.g. fatty acids, sugars, starch and dietary fibre (Becker et al., 2008, 2009; in Swedish). Results from the 2010 MB study have for the first time been compiled in one total report, including per capita exposure estimations for a large number of both nutrients and toxic compounds (NFA, 2012). As the study results from three time points could be compared (1999, 2005, 2010), possible time trends were also investigated.

MB studies and *total diet studies* (TDS) are interlinked concepts and are sometimes used to define the same type of study. An important TDS criterion is however that food samples should be analyzed as consumed, whereas MB studies are often analyzed as purchased. Examples of TDS studies are found e.g. in France (ANSES, 2011), Ireland (FSAI, 2011) and USA (Pennington, 2000). In Europe, the European Food Safety Authority (EFSA) has produced a guidance document on TDS for harmonisation purposes (EFSA, 2011). Recently, a book on TDS with explanation of basic principles

and methods and with examples from number of countries has been published (Moy and Vannoort, 2013).

As a further step in the harmonisation of TDS, the EU project TDS-Exposure has been run 2012-2016 with the participation of 19 EU-MS, including Sweden. The project has worked to find common methods, including quality management, for TDS and has encouraged contacts between member states in these matters. In addition to quality assurance issues, the projects has also dealt with questions regarding e.g. selection of food items, food preparation prior to analyses, sample homogeneity and chemical-analytical quality. So far, results from the project have partially been published (e.g. Vin et al., 2014; Papadopoulos et al., 2015).

For future Swedish MB studies, we will examine the TDS-Exposure project for improvement and possible harmonization. For example, NFA has already considered to prepare food as for consumtion prior to chemical analysis. Furthermore, it is also our ambition to compile present and earlier collected data in some kind of common data base, to improve data quality and facilitate future studies, e.g. on time trends. Also, in case of the need for analyses of "new" emerging compounds in food, we have the ambition to use banked food samples, when this is possible.

5. Food categories

The Swedish Board of Agriculture (SBA) produces regularly updated reports of per capita consumption data based on production and trade statistics, providing information on annual availability of foodstuffs on the Swedish market. In the present report, data on food purchase in the calendar year 2013 (SBA, 2013) has been used as basis for the calculations in this report. The statistics give information on annual market availability of food categories and foodstuffs. A shopping list was produced by breaking down the food categories presented in the SBA data table into food items using data for their market shares. Food groups consumed on average 0.5 kg per person per year (i.e. 1.5 g/p/day) or more were included. The list covers approximately 90% of the total annual consumption expressed in kg/person. Each basket represents more than 130 food items. Foods excluded were coffee and tea, household salt and alcoholic beverages, while beer with < 3.5 vol% alcohol (available in regular food stores) was included. In the 2015 MB supplementary purchase statistics for several food categories (meat cuts, prepared dishes, fish, edible fats, cereals, softdrinks, cordials and fruit juice) were obtained from the market research company Growth from Knowledge (GfK), Sweden. This is due to the lack of detailed data on fresh fish and on edible fats in the SBA report since year 2000. The GfK statistics are based on their consumer panels, and can be transformed into figures on the total consumption volume (in kg) and on some of the leading products and specific types or products of fish. Complementary data were also obtained from sales statistics provided by ICA AB and data from the food consumption survey Riksmaten 2010-11 adults (Amcoff et al., 2012). In Annex I, a detailed market basket shopping list is presented.

The food items in the purchased MB have been divided into 12 food main categories, based on the categorisation in the Swedish Food Circle (i.e. vegetables, fruit, potatoes, bread/cereals, dairy products, meat, fish, eggs and fats) in combination with categories defined in the SBA statistics (pastry/sweet bakery products, sugar/sweets and beverages) (Table 5:1). In case of dairy products, two groups were formed (solids and fluids) due to homogenization problems when dealing with the whole group. In addition, the meat group included a subgroup consisting of processed meats, and the pastry group included a pizza and pirogue subgroup. In these two latter cases these items were also included in the main groups (meat and pastry, respectively), but it was of interest to study these subgroups separately. The average daily intake of food components, the per capita inktake, was calculated by multiplying the concentration of these components by the amount of food representing daily consumption according to the statistics.

The food groups are generally analysed as purchased, which has been the standard procedure also in earlier market basket studies. However, as the levels of certain compounds could be altered (or some compounds even formed) as a consequence of various methods of food preparation, a pilot cooking study was included regarding some food groups (see Chapter 7). For this purpose, additional amounts of cereals, meat, fish and potato products were purchased in order to perform this pilot study.

Table 5:1. Food groups and major food items within each group, used in the Market Basket 2015 study. The food group weights represent 1% of the annual per capita weight, after removal of inedible parts

Group No.	Food group	Description of food items/categories	Wt. of food group homogenate (g)*	
			Not cooked	Cooked
1	Cereal products	Flour, grain, corn flakes, pasta, bread	836	1151/ 1169
2	Pastries	Biscuits, buns, cakes, pizza, pirogue	177	
2U	*subgroup*	*Pizza, pirogue*	*70*	
3	Meat	Incl. meat products; beef, pork, lamb, game, poultry, cured/processed meats	774	669/ 661
3U	*subgroup*	*Processed meats*	*207*	
4	Fish	Incl. fish products; fresh and frozen, canned, shellfish	167	161/ 156
5A	Dairy pr., fluids	Milk, sour milk, yoghurt	1180	
5B	Dairy pr., solids	Cheese (hard, processed, cottage), cream and sour cream	290	
6	Eggs	Fresh eggs	101	
7	Fats and oils	Butter, margarine, cooking oil, mayonnaise	164	
8	Vegetables	Fresh and frozen, incl. root vegetables, canned products	721	
9	Fruits	Fresh and frozen, canned products, juice, nuts, cordials, jam	851	
10	Potatoes	Fresh, French fries, potato crisps, potato purée (ready-made)	461	437/ 435
11	Sugar and Sweets	Sugar, honey, chocolate, sugar sweets, mustard, ketchup, dairy and vegetable fat-based ice-cream, ready-made sauces and dressings	459	
12	Beverages	Soft drinks, mineral water, beer (up to 3.5 vol. % alcohol)	1150	

* Food items from four food groups (cereals, meat, fish and potatoes) were in addition cooked before blending into the group homogenates, and the food group homogenates including cooked food items resulted in an altered weight, compared to the "standard" weights, before cooking. The pair of "cooked" weights represent food baskets from food chains City Gross and Willys, respectively (for more information see chapter 7)

6. Collection of food, handling of samples, selection of analytes

In the present study, all food items were collected from food stores in Uppsala. The decision to delete the regional sampling of food was taken already before the previous market basket study (Market Basket 2010), in which all food sampling was done in Uppsala. As stated in the previous report, evaluation of the results from the "regional" MB surveys in 1999 and 2005 (samples obtained from Malmö, Göteborg, Uppsala, Sundsvall) showed in most cases no significant and consistent difference between food baskets from these cities, and the conclusion was that sampling in one city was sufficient. In the present study all foods were thus purchased in Uppsala from five major grocery chains, with different distribution channels – Coop, ICA, Willys (Axfood), CityGross (Bergendahls), and Lidl. The purchases were all made in May-June 2015.

In contrary to the previous study in 2010, we did not collect additional food samples at other seasons of the year. In 2010, in addition to the general purchase of foods in May/June, sampling of vegetables, fruit and potatoes was also performed in Autumn/September to account for seasonal variations in levels of studied compounds. However, examination of Market Basket 2010 seasonal data (May/June – August/September) on selected mineral elements (Cd, Fe, Se) in vegetable, fruit and potato homogenates from the five grocery chains showed no significant difference in levels between the two seasons, except for one case (Se in vegetables, higher in Spring than in Autumn; unpublished data). Differences in nutrients, pesticides etc. could not be examined due to lack of Autumn data. Regarding pesticide data, a seasonal variation in pesticide levels has indeed been indicated (Littorin et al., 2005), but pesticides levels were very low in the MB 2010 study. Based on this (although limited) data set, we decided to omit the additional Autumn sampling and only use the ordinary sampling in May-June.

To conclude, five different food baskets were collected from these Uppsala grocery chains during May-June 2015, each consisting of about 250 food items. At the day or purchase, proper handling of the food items were done in order to keep cold and frozen food items in favorable condition during transport. When selecting a specific product out of the general description in the food list (Annex 1), we normally choose at least two different brands, namely 1) the nationally largest selling brand/product and 2) the most common of the grocery chain's own brand (if present). It should however be stressed that this MB study has not been design to compare levels between grocery chains, but to use several well-frequented chains to obtain a solid food sampling base to be used in this national per capita intake study.

From each of the purchased food baskets, food items were sorted in 12 main food categories with two additional sub-groups and dairy products split in two groups (see

table 5:1). From the Willys and City Gross grocery chains, food was purchased in sufficient quantities to also cover a pilot study on cooking and its possible effect on subsequent chemical analysis. The number of samples maximally available for analysis is given in Table 6:1.

Table 6:1. Number of samples maximally available for chemical analyses. For economical and other reasons, a lower number of samples were analysed for some compound groups (achieved by pooling of samples or analyzing only some food categories)

Grocery chain	No. of samples	Extra samples (cooking)	Total no.
Coop	15	-	15
ICA	15	-	15
Willys	15	4	19
City Gross	15	4	19
Lidl	15	-	15
Sum	75	8	83

In the strategy for selection of compounds to be analysed in the present MB 2015 we try to cover important nutrients and toxic compounds from a risk or benefit perspective. When such compounds have been included in earlier MB studies, it is of special importance to follow up levels in food, and per capita intake calculations, to reveal possible time trends (see e.g. dioxin/PCBs, Cd and Pb). At the same time, it is of importance to take into account new findings and reports from the scientific community and to monitor new compounds that could be future potential problems within the food sector. Chlorinated paraffins, studied for the first time in the present MB 2015 project, may be such an example, as the production in Asia, expecially China, of CPs in huge and increasing, and imported goods could result in CP levels also in Swedish foods. Lastly, the selection of analytes in MB 2015 is of course dependent on both reliable and sensitive analytical methods and on the financial resources for performing the analytical parts. Regarding financial resources, the support from the Swedish EPA has enabled us to significantly increase the number of analytes in the present study (see acknowledgement in Preface).

7. Cooking of food items prior to analysis

The 2015 MB was analysed as purchased, that is foods are not cooked prior to analysis. However, as cooking might affect food structure as well as content of various substances, four food groups (cereal products, meat, fish, potatoes) from two food chains (Willys and City Gross) were chosen to be analysed both as purchased and as consumed. The "analysed as consumed" approach is normally a standard procedure in total diet studies (TDS), and in an ambition to investigate similarities and difference between the two methods, a pilot study on cooking food before analysis was performed.

All foods were prepared individually and according to instructions on the packages if present. In cases were several preparation methods were suggested the first alternative was choosen. For example, for rice there was often two instructions on the packages, one using an excess amount of water and one to boil until all water had been absorbed. If instructions on packages were missing, the most common preparation method in the national dietary survey 'Riksmaten adults 2010-2011' (Amcoff et al., 2012) and cookbook recipes were used (Vår kokbok, 2013).

All food items were prepared at NFA on an Electrolux EKE 1600 stove or in an Electrolux EMS2840 microwave. Temperatures in the foods were measured using an instant-read thermometer (Testo 926). Temperatures in the pans were measured using an infrared thermometer (Sentry ST-630, Sentry optronics corp.). A count down/up timer from VWR was used for timing.

No ingredients, for example fat or salt, were added during cooking. Cold tap water was used for boiling food items.

7.1 Cooking utensils

Boiling/simmering
For boiling and simmering a saucepan of stainless steel and tap water was used.

Frying
For frying a nonstick skillet and a spatula of plastic or wood was used.

Ovenbaking
For owenbaking dishes of porcelain or glass were used.

Microwave
For microvawe heating the full effect of the oven was used, that is 900 W. To allow heat distribution, foods were left for a few minutes prior to weighing.

Water for cooking
The water used for boiling and simmering was cold tap water collected in the ordinary tap water system at NFA, Uppsala. The approximate levels of both essential and non-essential elements are presented in Table 7:1. The levels presented derive from tap water, sampled and analyzed at NFA, and/or from values received from Anna-Karin Söderstad, Uppsala Vatten, for tap water before entering the building of NFA. Note that analytical

methods with different limit of detection have been used and also that the copper levels increase around ten times after entering the water system of the building.

Table 7:1. Approximate levels of essential and non-essential elements in tap water sampled at National Food Agency (analysed at NFA) and at Stallängsgatan 3 (values received from Anna-Karin Söderstad, Uppsala Vatten) in the city of Uppsala, Sweden during 2015. Values from Uppsala Vatten represent the tap water before entering the building of NFA.

Sampling site	**Approximate levels in tap water**							
	mg/l							
	Al	**Ca**	**Cu**	**Fe**	**Mg**	**Mn**	**Na**	**Zn**
NFA	< 0.08		0.3	< 0.05		0.004		< 0.06
Uppsala Vatten	< 0.02	35	0.025	< 0.02	11	< 0.005	16	
	µg/l							
	Ag	**tAs**	**Cd**	**Co**	**Cr**	**Mo**	**Se**	
NFA	< 1	< 2	< 0.4	< 0.4	< 4	4	< 20	
Uppsala Vatten		< 0.3	0.008		0.1		< 20	
	V	**Hg**	**Ni**	**Pb**	**Sb**	**Sn**	**U**	
NFA	< 16	< 7	< 6	< 0.9	< 0.9	< 4	28	
Uppsala Vatten		< 0.002	0.6	0.08	0.08		18	

7.2 Yield factors

All foods were weighed before and after cooking to calculate the yield factor according to Bognar (Bognár and Piekarski, 2000):

$$\text{Yield factor} = \frac{\text{weight prepared food (g)}}{\text{weight raw food (g)}}$$

Prior to weighing foods were left to evaporate for up to half a minute after cooking.

The yield factor was used to calculate new food weights for the composite samples. Before pooling the samples into a ready-to-eat composite sample, all weights of the raw composite sample were multiplied with the yield factors. For example, the weight of the 'rice, longgrain' in the raw composite sample for cereals was 25 grams and the yield factor 2.83, thereby the weight of the composite ready-to-eat sample was 70.8 grams:

25 grams raw sample × 2.83 (yield factor, boiling)= 70.8 grams

Details for all cooked food items regarding cooking procedure, weights and yield factors are summarized in Annex II.

8. Chemical analysis and preparation of samples

8.1 Chemical analysis - general

In order to receive a useful result from a chemical analysis of a sample, a skilled and accurate planning of many parameters is required. The first and perhaps the most difficult task is to collect samples that give the correct answers. Questions like where, how and when to take the sample, and also how much of the sample you need to collect, need to be answered. This procedure is described above in chapter 6 "Collection of food, handling of samples, selection of analytes". Secondly, the samples need to be homogenous enough to be able to take out a small subsample, sometimes less than 1 g, for analysis. This sample should represent the composition of the whole original sample. In this work the original sample should represent what you commonly eat. For example, if apples are to be analysed both the peel and the fruit is homogenised (not the core), but for bananas the peels are taken away before homogenization. When performing homogenization of the samples the equipment used, i.e. grinders, mills, mixers and containers must be selected in order not to contaminate the sample. For example, if nickel and chromium are to be analysed, stainless steel knives should be avoided (but are used in our study) and for the analysis of organic contaminants like flame retardants and dioxins, plastic equipment should not be used. Since, in this work, the same samples are to be analysed for several compounds and elements, sometimes different setups of homogenization equipment would be required. This makes the homogenization procedure extensive and costly. In this work care to avoid any contamination has been taken in account as far as reasonably possible. A general approach has been to prepare the samples with carefully cleaned tools commonly used in a household kitchen, and after homogenisation store the samples for different analysis in appropriate containers. The procedures used are briefly described below in section 8.2, Preparation of samples for analysis, and in more details in Annex III, Sample preparation of food categories.

Before the samples could be analysed, different preparation procedures are required for the analytical methods used for the different compounds and elements. These procedures are described in respective sections below with the subtitle "Chemical analysis".

The results that finally are generated from the analytical methods are all containing some degree of uncertainty. This so called measurement uncertainty origins from the separate uncertainties in the different steps in handling the sample; from sample collecting, sample preparation, and the analytical measurement respectively. The size of the measurement uncertainty depend on risk of contamination, homogeneity of the sample, the concentration level of the analyte in the sample, and the performance of the analytical instrument. One way to express the measurement uncertainty is to calculate the total standard deviation of the analysis and multiply it with a factor 2, which is the coverage factor for 95 % confidence in the result. Such a measurement uncertainty could vary widely depending on the analyte and the analytical technique used, but figures between 10 and 40 % are often seen.

8.2 Preparation of samples for analysis

The collected food items were immediately taken care of. Fresh samples were kept in a refrigerator and frozen samples in a freezer until sample preparation. All equipment, such as mixers, stainless steel utilities, knifes, cutting boards, glass and plastic jars, were washed with a week detergent followed by careful rinsing with deionized water. Glass jars used for storage of samples for the analysis of flame retardants and dioxins were additionally rinsed with acetone prior to use, and plastic jars used for metal analysis were washed with 10 v/v % nitric acid (p.a). All sample preparation was made in a laboratory with yellow light (sodium lamp) in order not to affect the amount of light sensitive vitamins in the samples.

The samples to be analyzed, here called "homogenates", contain specific amounts of different food items (Table 5:1, Food groups and major food items). The characteristics among the different food items vary widely from liquid milk, fresh meat, and bananas to bread and dry yellow peas. Hence the sample preparation and homogenization vary accordingly.

8.2.1 Sample cleaning and peeling

All vegetables, fruits and potatoes were washed with deionized water. Inedible parts of the food items such as peel, bone, skin, etc. were removed. Stainless steel knives were used for the cutting and removal of inedible parts.

8.2.2 Homogenization and preparation of the homogenates

Before weighing the different food items and preparing the final homogenates, many of the food items were individually homogenized, for example meat, fish, pasta, bread, and müsli. Other food items like sausage, liverwurst, cheese, oat flakes, cookies, and fats, were by themselves regarded as "mixtures" and not individually homogenized before added to the homogenate. Liquid food like milk, oils and dressings were blended in their original container and then added to the respective homogenate. For the final blending and homogenization of the food items in order to prepare the homogenates, a food mixer was used (CutoMat Mixer S 100, Hug Elektromaschinenbau, Switzerland; with stainless steel bowl and knife). For a detailed description of the individual homogenization of each food item, see Annex III, Sample prep of food groups.

Each homogenate was divided in several portions and placed in appropriate containers for the different analyses. From each homogenate, a certain amount was also banked for possible future analytical purposes.

8.2.3 Storage

The homogenates and the blank samples were stored in appropriate containers in a - 20 °C freezer until analysis.

9. The per capita concept

The concepts per capita consumption (of food) and per capita exposure (to compounds, both nutritients and potentially harmful, found in food) are based on the SBA data on production and trade statistics. The first concept represents the calculated/estimated mean consumption, i.e. availability, derived from Swedish sales and production statistics by dividing the total volume (of a food item/category) by the number of inhabitants in Sweden. The second concept is derived by multiplying the per capita consumption figure for a specific food category by the concentration of the actual compound found in the food homogenate.

For example, let us say that we find a iron (Fe) concentration of 16.2 mg/kg fresh wt in a cereal homogenate. By multiplicating this figure with the weight of the homogenate (836 g = 0.836 kg; see Table 5:1) we obtain 1/100 (1%) of the yearly intake of Fe from cereals, as our homogenate represent 1% of the yearly consumption (estimated by SBA). A further multiplication with a factor 100 gives the yearly Fe intake, and by division with 365 (days per year) we get the intake per day from cereals. In our example, the daily Fe intake from cereals would be: (16.2 x 0.836 x 100) / 365 = 3.7 mg/per day. By performing this calculation for each food category/homogenate and adding up all Fe intakes, we obtain an estimated total daily Fe intake from food. In the previous market basket survey (Market Basket 2010; NFA, 2012) this total Fe intake was 11.4 mg/day and person. General formulas:

Conc. in food x homogenate weight x 100 / 365 = daily intake from specific food category, per person (A)

Addition of all separate intake from food homogenate/categories = Total daily intake from food, per person (B)

The above estimated intake is given on a per person basis. For toxic or potentially harmful compounds, it is important to present data also given on a body weight basis. In the previous Market Basket study of 2010, a mean weight of the whole population of 67.2 kg was estimated (NFA, 2012). However, to simplify and omit a recalculation of an actual mean population weight, we recommend this time to use the mean adult body weight reported in the Riksmaten 2010-11 adult survey (Amcoff et al., 2012): 69.1 kg för adult women and 84.1 kg för adult men. Assuming 50% of each gender, the preferable mixed adult body weight to be used in this report is 76.6 kg. The choice to use the presented adult mean weight, as compared to the previous estimated whole population mean weight, increases the mean weight by 14% ((76.6-67.2)/67.2 x 100). As the per capita body weight has been calculated in different way in the various market basket surveys, we prefer to use intake data as calculated per person, and not per kg body wt, when presenting time trend results.

In a pilot study, as part of the the present survey, we have for the first time also cooked food items belonging to the food categories cereals, fish, meat and potatoes, in order to look for possible effects of cooking on levels and intake of certain compounds (see Chapter 7). Here, yield factors were introduced to compensate for the change in weight

after the cooking procedure. By using these yield factors, the change in weight of a food group (e.g. rice, polished) was compensated for (by multiplicating the weight of the oncooked food group with the yield factor), and in this way, levels and estimated intakes of analysed compounds between uncooked and cooked food categories could be compared.

The MB approach used when estimating the Swedish average consumer's exposure is an indirect method of monitoring consumption, as we rely on data of food purchased in shops and not on information of the consumers own actual food consumption. Because of this, we have for instance no data on food waste in the retail sector or in households, even if we know that waste occurs (NFA and Swedish EPA, 2015; food wastage about 4-5% of the available Swedish food supply). However, all types of assessments of food consumption are suffering from errors or limitations of some kind, which may result in both under- and overestimations of the "real" consumption. Nevertheless, earlier Swedish MB results have shown a good correspondence between the mean exposure estimated in a population-based dietary survey, and by market basket results (e.g. dioxins -Darnerud et al., 2006; cadmium – Sand and Becker, 2012).

10. Per capita consumption – changes over time

The per capita intake is a function of both a) levels of the studied compounds in food and b) the consumption of the food groups, and the latter parameter is based on SBA:s annual compilation of the national food trade and consumption statistics. Consequently, if a time trend in per capita intake of a compound is suggested, the cause could be either changes in levels in food or changes in consumption, or both. The per capita consumption and its changes over time is therefore of interest to study as such, and the volumes and changes in consumption of the studied food groups from 1999 to 2015 is presented in Table 10:1, Fig. 10:1. The table shows that changes in estimated consumption is suggested over time, of which some are considerable (fruits consumption increased 39% from 1999 to 2015), but others insignificant (e.g. beverages, fats and oils). Of the twelve food groups, two groups suggest decreased consumption over time (dairy products and potatoes (10-13%)), whereas several other groups have increases to around and over 30% during the 1999-2015 time span (pastries, meat, vegetables, fruit, sugar and sweets). It should be noted that these changes cannot be directly translated into an altered energy intake, as the different food groups have various energy contents. In addition, the increase in consumption of certain food groups (cereals, fish, vegetables, fruit) is favourable from a dietary health point of view whereas the concomitant increases in meat, pastries and sugar/sweets are less recommendable.

The SBA has in its own recent report ("How the Swedish consumption has developed during the last 50 years, and why") presented figures on the Swedish food consumption, and the trends that are presented in our report are essentially the same as these shown by SBA, as our MB studies have been based on SBA per capita consumption data (SBA, 2015).

It is tempting to explain the changes in cer capita-consumption as a consequence of alterations primarily in consumer preferences and behaviours within the food area. However, there are also additional factors that could play a role. First, there has been a gradual increase in mean consumer age in the Swedish population resulting in an altered request for energy and consequently amount of food consumed. Second, as the per capita consumption is based on production and purchase figures, the amount of produced food that never is consumed, the food waste, is not seen by the market basket method and could also interfere with time trends if the amount of food waste is altered over time. Third, the method does not include food consumption that is based on home production (food produce, mushrooms, berries etc., that is not distributed and sold on the market) and this fact gives rise to uncertainties, also over time.

An additional difficulty with the SBA per capita figures is that data in some cases have been reported and aggregated in different ways during the time period 1999-2015. For instance, data on the category fats and oils are not completely comparably before and after 2005. These differences in data collection with time are described in SBA, 2015 (Annex 2, in Swedish). Also, for some food categories the SBA data were supplemented

with consumption figures from market research companies in order to obtained a better basis for the per capita intake calculations (see Chapter 5; meat cuts, fish, cereals etc) and this was done differently in the different MB studies. In addition, the weighing factors used to decide types of food within a food group (e.g. bread: white bread/mixed meal or sifted rye bread/wholemeal rye bread) are in many cases uncomplete and need updating.

The per capita body weight calculations have been based on different sources of body weight data, which is a source of error when comparing intake data from different MB surveys. Therefore, our time trend studies are based of per person intake values, and are not body weight adjusted.

Table 10:1;. The Swedish per capita consumption 1999-2015, at time points when market basket studies have been performed. The weight figures represent one percent of the annual per capita consumption.

Group	**Category**	**1% of annual per capita consumption (g)** [1]				
		MB 1999	*MB 2005*	*MB 2010*	*MB 2015*	*Change (%) 1999-2015*
1	Cereal products	694	911	844	836	20
2	Pastries	137	191	185	177	29
3	Meat	567	708	759	759	34
4	Fish	133	172	185	160	20
5	Dairy products	1685	1758	1557	1470	-13
6	Eggs	92	81	84	101	10
7	Fats and oils	175	144	145	165	-6
8	Vegetables	548	636	704	706	29
9	Fruits	641	683	867	889	39
10	Potatoes	514	443	458	461	-10
11	Sugar and sweets	353	378	453	459	30
12	Beverages	1188	1267	1205	1150	-3
	Total	6727	7372	7446	7333	9

1) The food items in these time trend compilations belong to the original SBA subgroup setting, and has not been adjusted to optimally fit the different food categories. For instance, in the 2015 Market Basket certain food items have been relocated to new food categories (e.g. soups from fruit group to their "logical" position – fish soup to fish, vegetable soup to vegetables and pea soup with meat to the meat category)

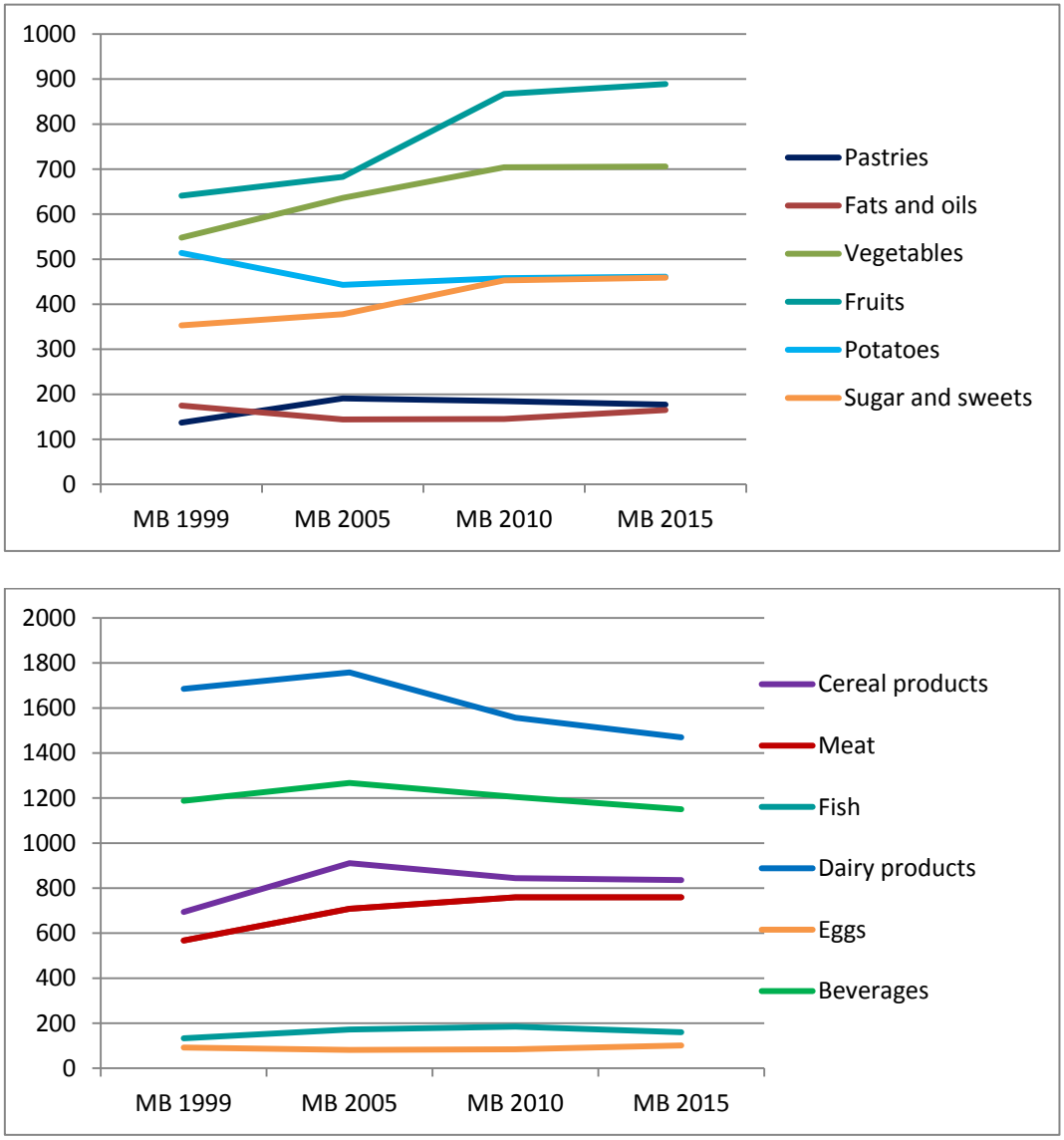


Figure 10:1. Swedish per capita consumption and changes over time. The four studied time points denote Swedish market basket studies. On y-axis, food weight in grams (1% of annual per capita consumption).

11. Chemical analyses, exposure and risk or benefit assessment

11.1 Macronutrients

11.1.1 Background

Macronutrients are nutrients that humans consume in larger quantities, i.e. water, fat, carbohydrates and proteins. Fat, carbohydrates, protein and dietary fibre (together with alcohol) provide us with energy and are found in almost all foods. However, in particular the fat and carbohydrate quality vary substantially. Hence NFA has dietary advice to make it easier to adopt healthy eating habits (NFA website, 2017). For example 'More vegetables and fruits; Eat lots of fruit, vegetables and berries; Ideally, choose high fibre vegs such as root vegetables, cabbage, cauliflower, broccoli, beans and onions.'

Fat. Fat provides energy and improves uptake of fat-soluble vitamins e.g. vitamin K. Fat in foods is mainly present as triacylglycerides, comprising a glycerol molecule and three fatty acids. The fatty acids linoleic acid (18:2 n-6) and alfa-linolenic acid (18:3 n-3) are essential for humans.

Carbohydrates. Carbohydrates may be divided into glycaemic carbohydrates that are digested and absorbed in the human small intestine and non-digestible carbohydrates commonly referred to as 'dietary fibre'. Some carbohydrates e.g. modified starches and some polyols are weakly glycaemic, or glycaemic to various extent. Glycaemic carbohydrates include mono- and disaccharides, starch and malto-oligosaccharides. Dietary fibre comprise a wide range of components that in various extent are fermented in the colon and contributes to faecal bulk by binding water. In the MB dietary fibre has been analysed as total dietary fibre (AOAC 985.29), which is a slightly different definition compared to EU regulation on food information (EU regulation 1169/2011). However, the chosen method is the same as in previous MB enabling time-trend analysis and in line with Nordic Nutrition Recommendations (NNR) (2012) enabling comparison between estimated and recommended intakes.

Protein. Protein provides energy and amino acids for the protein synthesis within the body. Protein in food is built of 20 amino acids of which 9 are essential for humans.

11.1.2 Chemical analysis

Total fat, individual fatty acids, mono- and disaccharides, starch and dietary fibre were analysed in this MB study and the previous ones in 2005 and 2010. In this MB protein,

water and ash was determined for the first time. Food samples from the different stores were merged prior to analysis, resulting in one sample per food category.

Analyses of total fat, dietary fiber, protein (as nitrogen), water and ash were arranged for by ALS Scandinavia AB, Täby, Sweden. Analysis of fatty acids, mono- and disaccharides and starch were carried out by ALcontrol, Linköping, Sweden. Both laboratories have a long history of working with nutritional analyses and quality assurance. Methods were accredited for all analytes except for individual fatty acids. The quality of the analytical work is ensured by a quality system and external and internal audits.

Total fat was analysed in November 2015 with an accredited (the United Kingdom Accreditation Service) NMR method according to ISA 8626. The limit of quantification (LOQ) was 0.1 g/100 g. Fatty acids were analysed in November 2015 using a GC-method accredited (SWEDAC, Swedish Board for Accreditation and Conformity Assessment) for sum of fatty acids (saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, trans-fatty acids, n-3 fatty acids and n-6 fatty acids). LOQ was 0.1 % for each fatty acid.

Dietary fibre was analysed with an accredited (the United Kingdom Accreditation Service) enzymatic, gravimetric standard method according to AOAC (AOAC 985.29). LOQ was 0.5 g/100 g. The fiber method does not include determination of non-available oligosaccharides as included in the definition by EU (EU regulation 1169/2011). Thereby the results will underestimate content and consequently average intake. However, using the same method as previous MB enables time-trend analyses, and furthermore Nordic (and other) nutrient recommendations are set using this definition. Sugars (glucose, fructose, sucrose, and maltose) were analysed with an accredited (SWEDAC) HPLC-CAD method. LOQ was 0.1 g/100 g for each mono-/disaccharide. Starch was analysed with an accredited (SWEDAC) method according to NMKL 145. LOQ was 0.2 g/100 g.

Nitrogen (for calculation of protein) was analysed in May 2017 using Dumas method accredited by the United Kingdom Accreditation Service. LOQ was 0.3 g/100 g. Protein content was calculated using the standard nitrogen conversion factor of 6.25 (EU regulation 1169/2011).

Ash and water was analysed in May 2017 with accredited (the United Kingdom Accreditation Service) gravimetric methods after drying at 105°C (water) and 550°C (ash). LOQ was 0.1 g/100 g for water and 0.06 g/100 g for ash.

Total carbohydrate was calculated by difference, i.e. 100 g – (water (g/100g) + ash (g/100g) + fat (g/100g) + protein (g/100g) + dietary fibre (g/100g)).

11.1.3 Analytical results

Fat and fatty acids

Concentrations of total fat and fatty acids are presented in Table 11.1:1. Individual fatty acids including trans-fatty acids are presented in Annex IV, V. If possible, fat and fatty acid content was evaluated using the EU regulation for nutrient claims (EU regulation 1924/2006). Nutrient claims are not intended for food groups. Hence the use of the definitions for claims in the MB should only be considered as guidance to when a nutrient

in average is present in an amount considered significant in a food group. Furthermore, individual food items might be 'low in' or 'source of' although present in food groups having an average content below the requirement for that nutrient.

Fat. The highest concentration of fat was found in the food categories 'fats and oils' (69 g/100 g), 'dairy products – solid' (i.e. butter, margarine including low-fat, mayonnaise and oil) (26 g/100 g) and 'cured processed meat products' (22 g/100 g) (Table 11.1:1 and Fig. 11.1:1). According to the EU regulation on nutrition and health claims made on foods (EU regulation 1924/2006) a food item containing less than 1.5 g fat per 100 g may be considered 'low-fat'. Only 'vegetables' contained in average less than 1.5 g fat per 100 g.

Major fatty acid categories. Fat quality is mainly determined by the proportions of the different fatty acids (presented in Annex IV). The food groups that contained the highest proportion of saturated fatty acids were 'dairy products' (67 % saturated fatty acids), 'sugar and sweets' (47 % saturated fatty acids), 'pastries' (39 % saturated fatty acids) and 'meat' (39 % saturated fatty acids). The proportion of monounsaturated fatty acids was highest in 'potatoes' (67 %) followed by 'meat', 'fish', 'fruit' and 'eggs' all containing at least 50 % of monounsaturated fatty acids. The proportion of polyunsaturated fatty acids was highest in 'cereal products' (39 %), 'fish' (33 %) and 'fruits' (29 %). According to the EU regulation on nutrition and health claims made on foods (EU regulation 1924/2006) a claim that a food is low in saturated fat may only be made where the sum of saturated fatty acids and trans-fatty acids does not exceed 1.5 g per 100 g or 0.75 g per 100 ml for beverages. 'Vegetables', 'potatoes', 'fruits', 'cereal products' and 'dairy products, fluid' contained in average less than 1.5 g saturated fat per 100 g. Fat and fatty acids were not analysed in 'beverages'.

Minor fatty acid categories. Concentrations of trans-fatty acids were below 0.1 g/100 g food, except for in 'dairy products solid' and 'fats and oils' containing 0.4-0.6 g trans-fatty acids per 100 g. In all food groups, trans fatty acid concentrations were below 1 % of total fatty acids, except for in dairy products (Annex V).

'Fish' and 'fats and oils' had the highest content of n-3 fatty acids whereas content of n-6 fatty acids were highest in the food groups: 'fats and oils', 'fish', 'cured processed meats' and 'pastries'. A claim that a food is a source of omega-3 fatty acids (i.e. n-3 fatty acids), may only be made where the product contains at least 0.3 g alpha-linolenic acid per 100 g and per 100 kcal, or at least 40 mg of the sum of eicosapentaenoic acid and docosahexaenoic acid per 100 g and per 100 kcal (Commission regulation (EU) 116/2010). Using this definition 'fish' was in average high in omega-3 fatty acids (n-3 fatty acids). Although 'fats and oils', 'pastries' and 'sugar and sweets' contained more than 0.3 g alpha-linolenic acid per 100 g, the content was estimated to be too low per 100 kcal. (Energy content is presented in Table 11.1:3.)

Table 11.1:1. Concentrations of fat and fatty acids in the food groups (g/100 g).

Food Category	Conversion factor	Fat	SFA	MUFA	PUFA	TFA	n-6 FA	n-3 FA
Cereal products	0.70	3.0	0.38	0.90	0.82	<LOQ	0.72	0.10

Pastries	0.95	14	5.1	5.9	2.2	0.05	1.7	0.44
Meat	0.95	12.1	4.5	5.8	1.1	0.09	0.97	0.10
Subgroup processed meats	0.95	21.6	8.2	10	2.1	0.04	2.0	0.16
Fish	0.90	11.8	1.6	5.6	3.5	<LOQ	2.1	1.4
Dairy products fluids	0.95	1.6	1.0	0.40	0.05	0.04	0.03	0.01
Dairy products solids	0.95	26	17	6.6	0.82	0.64	0.52	0.15
Eggs	0.83	8.6	2.0	3.7	1.5	0.01	1.3	0.19
Fats and oils	0.96	69	22	30	13	0.39	9.7	3.1
Vegetables	0.80	0.4	0.10	0.03	0.20	<LOQ	0.12	0.07
Fruits	0.80	1.7	0.23	0.74	0.39	<LOQ	0.34	0.05
Potatoes	0.95	2.1	0.20	1.3	0.46	<LOQ	0.45	0.01
Sugar and sweets	0.95	17	7.5	6.7	1.8	<LOQ	1.4	0.43

Sampling in 2015. Conversion factor – applied to total fat to give values for total fatty acids in the fat; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; TFA – trans fatty acids; n-3 FA – n-3 fatty acids; n-6 FA – n-6 fatty acids. Of the 45 fatty acids included in the method a few were not detected in any sample (11:0, 13:0, 21:0, 23:0, 24:0, 22:2). Positional isomers of unsaturated acids were not further specified. LOQ – limit of quantification, <LOQ: proportion of the fatty acid was <0.1% of total fatty acids.

Carbohydrates

The concentrations of carbohydrate constituents in the food groups are given in Table 11.1:2 and 11.1:3. If possible, carbohydrate content was evaluated using the EU regulation for nutrient claims (EU regulation 1924/2006). Nutrient claims are not intended for food groups. Hence the use of the definitions for claims in the MB should only be considered as guidance to when a nutrient in average is present in an amount considered significant in a food group. Furthermore, individual food items might be 'source of' or 'low in' a nutrient although present in food groups having an average content below the requirement for that nutrient.

Starch. The starch content was highest in 'cereal products' (70 %), followed by 'potatoes' (12 %) and 'pastries' (8 %).

Dietary fiber. The highest concentrations of dietary fiber were found in 'cereal products' (46 %), 'pastries' (4 %) and 'potatoes' (11 %). Results are suitable for time-trend analysis (Figure 11.1:4) since the method (AOAC 985.29) is the same as previously used. However, results are underestimated according to the definition in the EU regulation on food information (EU regulation 1169/2011) as the used method does not include oligosaccharides in the fiber fraction. A claim that a food is a source of fibre, and any claim likely to have the same meaning for the consumer, may only be made where the product contains at least 3 g of fibre per 100 g or at least 1.5 g of fibre per 100 kcal. Only 'cereal products' contain more than 3 g per 100 g. However, 'vegetables', 'fruits', 'potatoes' and 'cereals' contained more than 1.5 g fibre per 100 kcal (Table 11.1:2).

Table 11.1:2. Concentrations of carbohydrates in the food groups (g/100 g).

Food Category	Starch	Fibre	Fibre per 100 kcal	Sum of sugars	Fru	Glu	Suc	Mal	Lac[2]
Cereal products	43	4.8	2.9	4.5	0.96	0.96	0.33	2.0	0.21
Pastries	24	2.2	1.2	17	1.8	2.2	12	0.59	<0.03
Meat	1.7	<0.5	<0.5		<0.1	<0.1	<0.1	<0.1	
Subgroup processed meats	2.5	<0.5	<0.5	1	<0.1	0.11	<0.1	<0.1	0.09
Fish	1.7	0.7	0.7	0.3	0.19	<0.1	<0.1	<0.1	0.07
Dairy products, fluids	<0.2	<0.5	<0.5		<0.1	<0.1	0.30	<0.1	
Dairy products, solids	<0.2	<0.5	<0.5	4	<0.1	<0.1	<0.1	<0.1	3.5
Eggs	<0.2	<0.5	<0.5	0.2	<0.1	0.23	<0.1	<0.1	n.a.
Fats and oils	0.2	<0.5	<0.5	0	<0.1	<0.1	<0.1	<0.1	n.a.
Vegetables	0.2	1.8	11.7	3.2	1.6	1.6	<0.1	<0.1	<0.03
Fruits	1.2	1.5	3.0	25	12	13	<0.1	<0.1	<0.03
Potatoes	13	2.0	3.5	0.4	<0.1	0.20	<0.1	0.16	<0.03
Sugar and sweets	4.3	1.6	0.8	41	2.6	4.1	31	0.94	2.1
Beverages	0.2	n.a.	n.a.	3.5	<0.1	<0.1	3.5	<0.1	<0.03

Sampling in 2015; fru – fructose, glu – glucose, suc- sucrose, mal – maltose, lac – lactose.
[1]Calculated using the energy content presented in Table 11.1:3. [2] Lactose concentrations from MB study 2010 (no analysis of subgroups). < indicate a value below limit of quantification, e.g. 0.2 g/100 g for starch.

Sugar. Sugar content was highest in the sugar and sweets group (40 g/100 g), followed by 'fruits' (25 g/100 g) and 'pastries' (17 g/100 g). In 'fruits' sugar was present as glucose and fructose, whereas sucrose dominated in 'sugar and sweets' and 'pastries'. Maltose was mainly found in 'cereal products'. According to the EU regulation on nutrition and health claims made on foods (EU regulation 1924/2006) a claim that a food is low in sugar may only be made where the product contains no more than 5 g of sugar per 100 g for solids or 2.5 g of sugar per 100 ml for liquids. Average sugar content in the food groups was below 5 g per 100 g in all food groups except for 'pastries', 'fruits' and 'sugar and sweets'.

Carbohydrates by difference. Carbohydrate content was highest in 'cereal products' (58 g/100 g), followed by 'sugar and sweets' (50 g/100 g) and 'pastries' (48 g/100 g) (Table 11.1:3).

Table 11.1:3. Macronutrients (g/100 g) and energy content (kJ/100 g).

Food Category	Water	Ash	Fat	Nitrogen	Protein	Fibre	Carbo-hydrates	Energy	Energy from protein (%)
Cereal products	23.8	1.3	3.0	1.51	9.46	0.33	58	1290	12
Pastries	27.7	1.5	14	1.11	6.95	12	48	1460	8
Meat	68.7	1.6	12.1	3.22	20.1	<0.1	0	790	43
Fish	66	2.1	11.8	2.34	14.6	<0.1	5	770	32
Dairy products, fluids	89.2	0.7	1.6	0.541	3.38	0.30	5	200	28
Dairy products, solids	54.2	2.1	26	2.37	14.8	<0.1	3	1265	20
Eggs	76.3	0.9	8.6	1.9	11.9	<0.1	2	560	36
Fats and oils	28.9	1.2	69	0.056	0.35	<0.1	1	2570	0
Vegetables	91.9	0.6	0.4	0.205	1.28	<0.1	4	120	18
Fruits	78.1	0.5	1.7	0.208	1.3	<0.1	17	380	6
Potatoes	74.5	0.9	2.1	0.322	2.01	<0.1	18	440	8
Sugar and sweets	27.3	1.3	17	0.488	3.05	31	50	1540	3

Sampling in 2015; < indicate a value below limit of quantification, e.g. 0.5 g/100 g for fibre.
Protein content was calculated using the standard nitrogen conversion factor of 6.25 (EU regulation 1169/2011). Conversion factor from kJ to kcal is 0.24.

Protein

Protein content is given in Table 11.1:3. If possible, protein content was evaluated using the EU regulation for nutrient claims (EU regulation 1924/2006). The use of the definitions for nutrient claims in the MB should only be considered as guidance to when a nutrient in average is present in an amount considered significant in a food group. Furthermore, individual food items might be 'source of' protein although present in food groups having an average content below the requirement. A claim that a food is a source of protein may only be made where at least 12 % of the energy value of the food is provided by protein. A claim that a food is high in protein, and any claim likely to have the same meaning for the consumer, may only be made where at least 20 % of the energy value of the food is provided by protein. In 'meat', 'fish', 'eggs' and 'dairy products' at least 20% of the energy came from protein. In 'vegetables' and 'cereal products' at least 12% of the energy came from protein.

11.1.4 Exposure estimation, time trends

Fat. Estimated average daily intake of fat and major fatty acid categories are summarised in Table 11.1:4. Contribution of each food group to estimated intake of fat and fatty acids is illustrated in Fig. 11.1:1. The change in estimated intake of fat and fatty acids since 2005 is illustrated in Fig. 11.1:2.

Estimated fat intake (130 g/person and day) was substantially higher than in 2010 (116 g/day and person) due to higher fat contribution from 'sugar and sweets' (+ 30%), 'dairy products' (+21 %) and 'fats and oils' (+ 17%). The higher fat contribution from 'fats and oils' might be explained by higher consumption of 'fats and oils' since 2010 (+5.5 g per person and day) contributing with an additional 4 g of fat. Consumption of 'dairy products' has decreased since 2010 whereas 'sugar and sweet' consumption has not been

altered (Table 10:1). This indicates that food preferences within those food groups and/or the fat content of food items within the food groups have changed. E.g. compared to previous MB a greater proportion of the 'dairy products' was whipped cream containing 40% fat. The higher fat content in 'sugar and sweets' might be explained by slightly higher amount of chocolate in the sample and/or by an increased fat content in those products. Furthermore, it is important to notice that current method for fat analyses – NMR (nuclear magnetic resonance) – is based on direct measurements of the nuclear NMR response of fat, which is different from the gravimetric methods previously used for MB. One advantage with using NMR is that homogenisation is not as critical as for the traditional methods. The accuracy of the analysed fat content in the food groups were controlled towards in-house fat analyses prior to determination of dioxin and brominated flame retardants (BFR). There were no difference between the fat contents obtained using NMR and with the method used prior to determination of BFR (n=30, P=0.78). However, compared with the method used prior to dioxin determination a higher fat content was found using NMR in the food category 'fish' (n=7, p=0.028).

Estimated fat intake from pastries (Table 11.1:4) was substantially lower than in 2010. This might be explained by some changes in the consumption patterns within this category. For example the proportion of pizza, having lower fat content than the remaining sweet pastries in the food group, was greater. In addition, Danish pastry was excluded from the food group.

Table 11.1:4. Average daily per capita intake of total fat and major fatty acid categories (grams)

Food group	Total fat	SFA	MUFA	PUFA	TFA	n-6 FA	n-3 FA
Cereal products	6.9	0.86	2.1	1.9	0	1.7	0.23
Pastries	6.7	2.5	2.8	1.0	0.03	0.83	0.21
Meat	26	9.6	12	2.3	0.20	2.1	0.22
subgroup processed meats	12	4.7	5.8	1.2	0.02	1.1	0.09
Fish	5.4	0.71	2.6	1.6	0	0.95	0.61
Dairy products, fluids	21	13	5.2	0.65	0.51	0.41	0.12
Dairy product,s solids	5.2	3.3	1.3	0.17	0.14	0.11	0.03
Eggs	2.4	0.54	1.0	0.42	0	0.36	0.05
Fats and oils	31	9.7	14	5.8	0.18	4.4	1.4
Vegetables	0.79	0.19	0.06	0.39	0	0.24	0.14
Fruits	4.0	0.54	1.7	0.92	0	0.79	0.12
Potatoes	2.7	0.25	1.7	0.58	0	0.57	0.02
Sugar and sweets	21	9.4	8.4	2.3	0	1.7	0.54
Beverages	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Sum	130	51	53	18	1.0	14	3.7
% of total FA		42	43	15	0.9	12	3
MB 2010[1]	*116*	*48*	*42*	*15*	*1.7*	*12*	*3.3*
Riksmaten adults[2]	*77*	*30*	*29*	*13*	*n.d.*	*9.4*	*2.7*

SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; TFA – trans fatty acids; n-3 FA – n-3 fatty acids; n-6 FA – n-6 fatty acids. n.a. – not applicable. n.d. – no data. Values for the subgroup 'cured/processed meats are included in the meat group. [1]NFA, 2012; [2]Amcoff et al 2012

Major fatty acid categories. Main contributor to estimated intake of saturated fatty acids was ‘dairy products fluid’ (26 %) whereas ‘fats and oils’ contributed the most to estimated intake of monounsaturated fatty acids (26%) and polyunsaturated fatty acids (32%). The higher estimated fat intake compared to MB 2010 resulted in a higher intake of monounsaturated fatty acids (+11 %) but also slightly higher intake of polyunsaturated fatty acids (+2.7 %) and saturated fatty acids (+2.5 %).

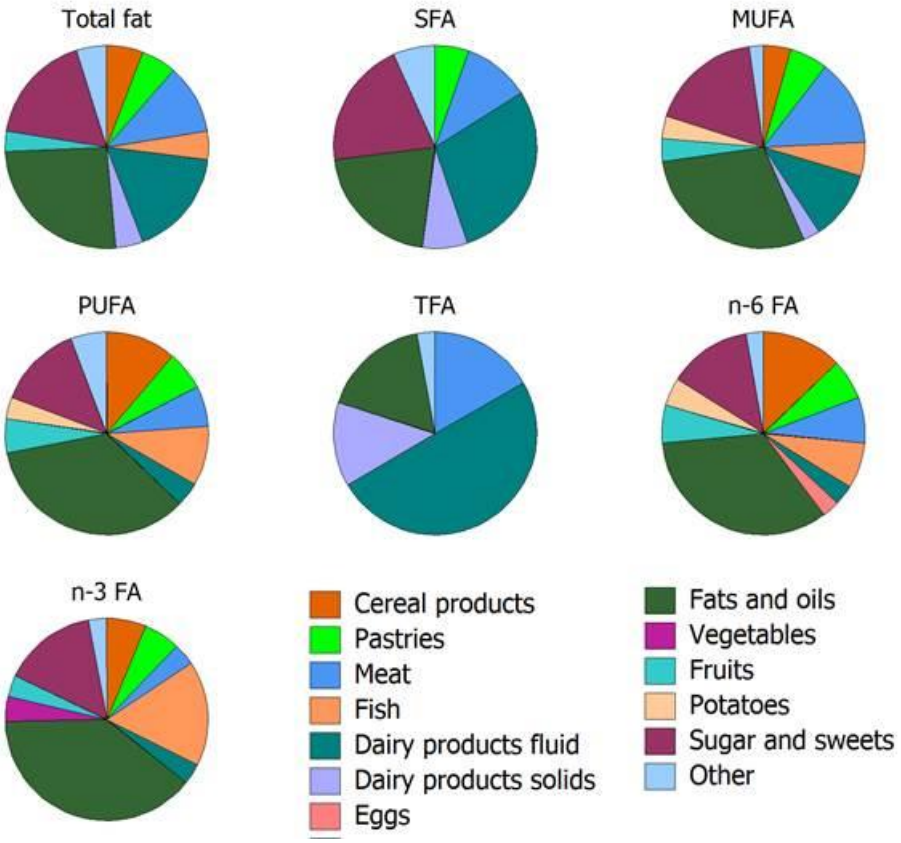


Figure 11.1:1. Percentage contribution to estimated intake of fat and fatty acid categories from different food groups. Food groups contributing with less than 2.5% of estimated intakes are summarised as ‘Other’.

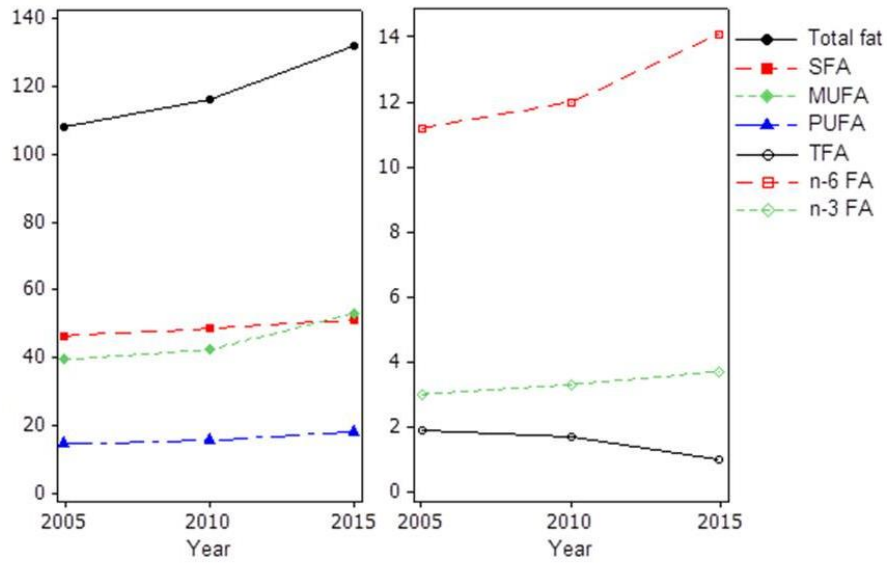


Figure 11.1:2. Estimated average intake of fat in market baskets over time (gram per person and day).

Minor fatty acid categories. The ratio of n-6 to n-3 fatty acids was 3.8, which was similar as 2010 (3.7). Main contributor to estimated intake of trans fatty acids was 'dairy products fluids' (49 %) whereas 'fats and oils' contributed the most to estimated intake of n-6 fatty acids (31%) and n-3 fatty acids (38%). 'Sugar and sweets' contributed nearly as much as 'fish' to the estimated daily intake of n-3 fatty acids (Table 11.1:4). This is due to a nearly 3 times greater consumption of 'sugar and sweets' than 'fish' (Table 10:1). Estimated intake of DHA (22:6 n-3) was 190 mg per day.

Carbohydrates. Estimated average daily intake of carbohydrates was about 320 g per person and day and of dietary fibre 24 g (Table 11.1:5). Contribution of each food group to estimated intake of carbohydrate constituents is illustrated in Fig. 11.1:3. Changes in estimated intake of carbohydrate constituents since 2005 are illustrated in Fig. 11.1:4.

Starch. Estimated daily per capita intake of starch was 140 grams (Table 11.1:5), about 25 grams lower than the MB study 2005 (Fig. 11.1:4). 'Cereal products', 'potatoes' and 'pastries' contributed with 90 % of the intake of starch (Fig. 11.1:3).

Table 11.1:5. Average daily per capita intake of carbohydrates (grams)

Food group	Starch	Fibre	Sum of sugars	Fru	Glu	Suc	Mal	Lac[1]	Glycaemic CHO	CHO by difference
Cereal products	98	11	10	2.2	2.2	0.76	4.6	0.49	110	132
Pastries	12	1.1	8.1	0.87	1.1	5.8	0.29	0	20	23
Meat	5.0	0	0.26	0	0.06	0	0		5.3	0
subgroup processed meats	1.4	0	0.06	0	0.06	0	0	0.20	1.5	0
Fish	0.78	0.32	0.13	0.09	0	0	0	0.04	0.90	2.2
Dairy products, fluids	0	0	16	0	0	0.97	0	15	16[1]	17
Dairy products,	0	0		0	0	0	0			

solids										
Eggs	0	0	0.06	0	0.06	0	0	0	0.06	2.3
Fats and oils	0.09	0	0	0	0	0	0	0	0.09	0.25
Vegetables	0.47	3.6	6.3	3.2	3.2	0	0	0	6.8	7.9
Fruits	2.8	3.5	58	28	30	0	0	0	61	39
Potatoes	16	2.5	0.45	0	0.25	0	0.20	0	17	23
Sugar and sweets	5.4	2.0	51	3.3	5.2	39	1.2	2.6	57	63
Beverages	0.69	n.a.	11	0	0	11	0	0	12	12[2]
Sum	140	24	160	38	42	58	6.3	18	300	322
MB 2010[3]	*149*	*21*	*179*	*32*	*32*	*88*	*8*	*18*	*328*	*n.d.*
Riksmaten adults[4]	*n.d.*	*20*	*88*		*31*	*39*	*n.d.*	*n.d.*	*n.d.*	*212*

fru – fructose, glu – glucose, suc- sucrose, mal – maltose, lac – lactose, CHO - carbohydrates. Estimated intakes less than 0.005 grams per day and person are set to 0. Values for the subgroup 'cured/processed meats are included in the meat group. [1]Lactose concentrations from MB study 2010 was included, in 2010 subgroups were not analysed thus only one concentration is given for 'meat' and one for 'dairy products', [2]glycaemic carbohydrates, [3] NFA 2012, [4]Amcoff et al 2012

Fibre. Estimated fibre intake is similar as in MB 2005 (Fig. 11.1:4, 25 grams per person and day) about 24 grams per person and day (Table 11.1:5). 'Cereal products', 'vegetables' and 'fruits' contributed with 75 % of the intake and 'potatoes' contributed an additional 10 % (Fig. 11.1:3).

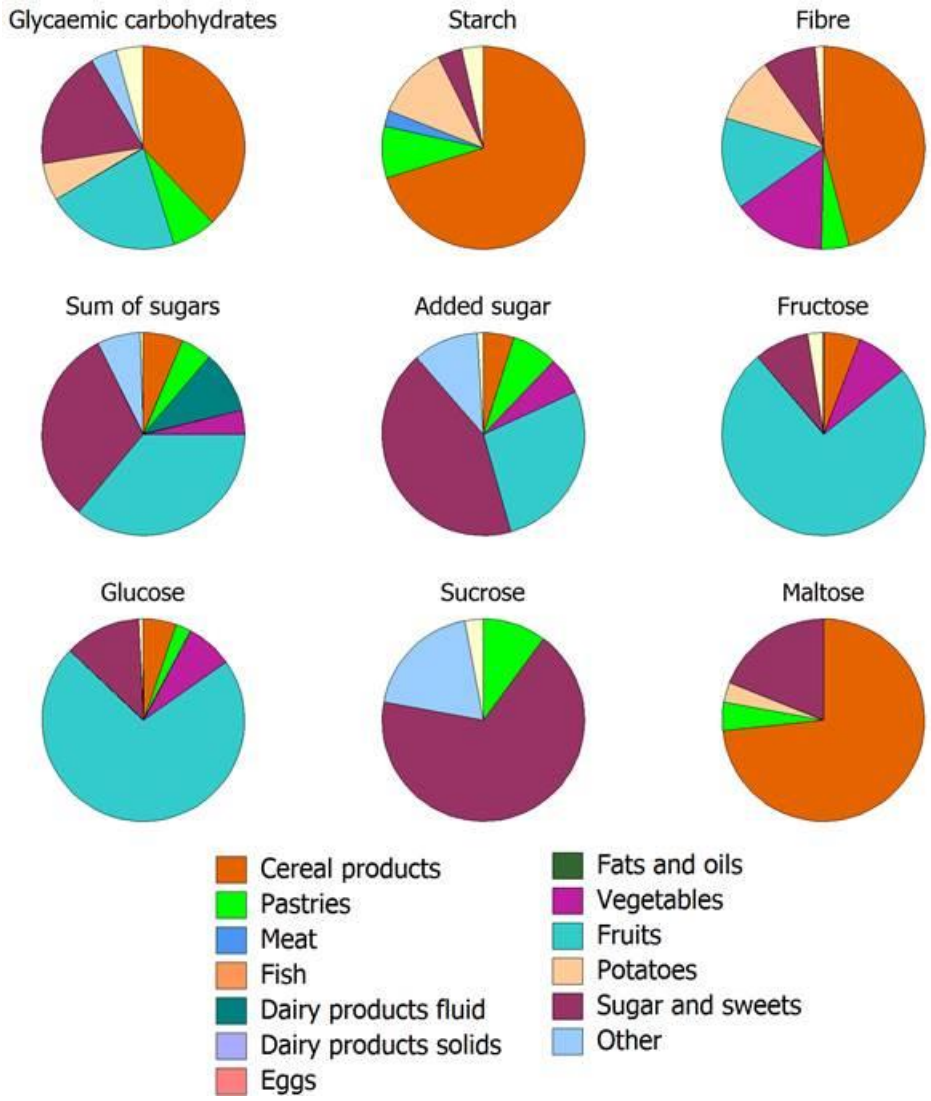


Figure 11.1:3. Percentage contribution to estimated intake of carbohydrates from different food groups. Food groups contributing with less than 2.5% to estimated intakes are summarised as 'Other'. Added sugar was estimated by adding fructose, glucose and sucrose and then subtract fructose, glucose and sucrose naturally present in the following groups: 'fruit', 'vegetables', 'potatoes' and 'cereals'.

Sugars. Estimated daily per capita intake of sugar (mono- and disaccharides) was 160 grams (Table 11.1:5), which was about 20 grams lower than the MB study 2010 (Fig. 11.1:4). 'Fruits' and 'sugar and sweets' contributed with nearly 70 % of the intake of sugar (Fig. 11.1:3).

Estimated intake of sucrose was about 35 % lower than in the MB study of 2010. This corresponds to 30 grams of sucrose (Table 11.1:5), as a result of lower contents in 'pastries', 'sugar and sweets' and 'fruits'. This decrease in estimated intake was partly replaced by increased intakes of fructose and glucose compared to the MB study 2010, 20 and 30 % higher respectively. New foods in the fruit group – strawberry jam, apple sauce

and orange marmalade – were high in glucose, fructose and sucrose compared to other foods within the group such as fresh fruits, berries and juice (Öhrvik et al., 2015; Öhrvik et al., 2016a).

Estimated sugar intake from ’pastries’ (Table 11.1:5) was substantially lower than in 2010. This might be explained by some changes in the consumption patterns within this category. For example the proportion of pizza, having lower sugar content than the remaining sweet pastries in the food group, was greater than in 2010 MB. In addition, Danish pastry was excluded from the food group.

Added sugar was defined according to NNR (2012) as refined sugars added during cooking or manufacturing. By using this definition, the following sweeteners should be considered added sugars: sugar (granulated, brown, powdered and maple); monosaccharides and disaccharides (e.g., fructose, lactose, maltose, glucose); single-ingredient syrups (light corn, dark corn, high-fructose corn, maple, malt, sorghum); honey and molasses; and maltodextrin (NNR, 2012). Added sugar was estimated to 80-85 grams per person and day by using a modified version of the standardized method suggested by Louie et al. (2015):

1. Sum content of fructose, glucose and sucrose for all food groups.
2. Subtract natural sugar in the fruit group from the sum. For sugar in fruits 4.4 g/100 g was estimated to be added by multiplying food items containing added sugar (i.e. jam, sauce and sweetened beverages, in total 17% of the fruit group) with the amount of added sugar according to labelling or analytical values for each food item. The remaining part was estimated to be natural sugar in fruits.
3. Subtract natural sugar in the vegetable group from the sum. All sugar in this group was natural, except for pickled cucumber, which contained about 2 g added sugar/100 g and comprised 4% of the vegetable sample, thereby estimated added sugar in the vegetable group was 0.08 g/100 g.
4. Subtract natural sugar in the cereal group from the sum. For sugar in cereals 4.1 g/100 g was estimated to be added by multiplying food items containing added sugar (i.e. special K, muesli, ‘havrefras’ and bread, in total 73% of the cereal group) with the amount of added sugar according to labelling or analytical values for each food item. As content of fructose, glucose and sucrose was 2.3 g/100 g all fructose, glucose and sucrose were estimated to be added in cereals (although a minor part is natural from fruits and berries in muesli). That estimated content of added sugar was higher than analysed total content indicates the difficulties with estimation of added sugar.
5. Subtract natural sugar in the potatoe group from the sum. All sugar in this group was considered natural.
6. Add added lactose in the ‘sugar and sweets’ group to the sum. No addition of lactose in the sugar and sweets group was assumed. The different analysed chocolate products (19% of the sample) contained milk powder contributing with lactose, however this was not considered as added sugar.

The estimated average intake of 80-85 g added sugar per day and person is lower than estimated in the MB 2010 (112 g) but higher than the 48 g estimated in Riksmaten adults 2010-2011 (Amcoff et al., 2012). However, this might be explained by the MB overestimating intakes as food waste is not taken into account (chapter 13) in combination with participants tending to underestimate their intake of unhealthy foods in dietary surveys.

No time-trend analysis was done due to the uncertainty in the estimations of added sugar. However, it is possible that intake of added sugar has decreased since 2010 as e.g. sucrose decreased by 30 g per person and day. This decrease was only partly explained by the higher estimated intakes of glucose and fructose. In e.g. USA a decrease in intake of added sugar was observed between 1999–2000 (100 g per person and day) and 2007–2008 (77 g) (Welsh et al., 2011).

Glycaemic carbohydrates. Estimated intake of glycaemic carbohydrates was about 25 grams lower per person and day than estimated in MB 2010 (Figure 11.1:4). This was mainly due to lower intake of starch and sucrose. 'Cereal products', 'fruits' and 'sugar and sweets' was the main contributors to intake of glycaemic carbohydrates (Figure 11.1:3).

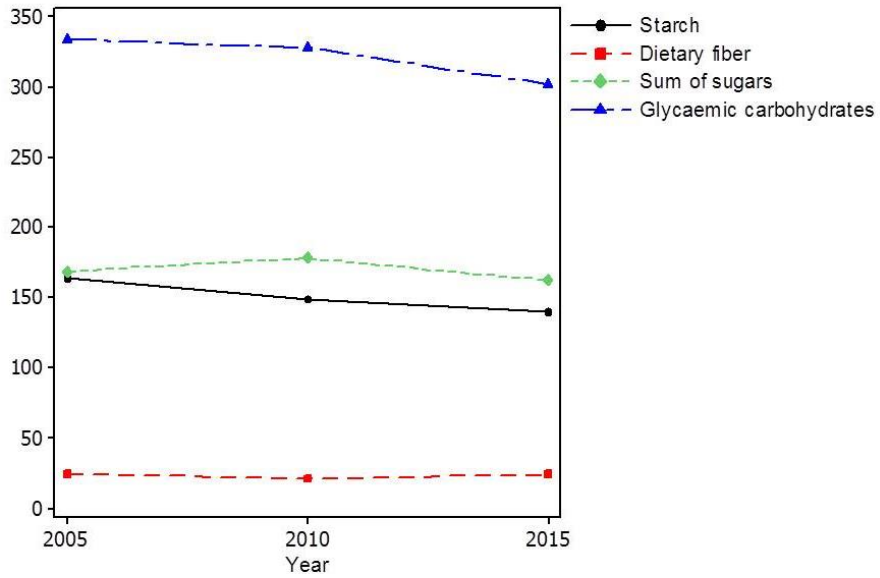


Figure 11.1:4. Average estimated intake of carbohydrates in market baskets over time (g per person and day).

Carbohydrate by difference. Estimated daily per capita intake of carbohydrate by difference was 322 grams (Table 11.1:5). 'Cereal products', 'sugar and sweets' and 'fruit' contributed with more than 70 % of the estimated intake of carbohydrates.

Table 11.1:6. Average daily per capita intake of protein (g) and energy (kJ) per person and day

Food group	Protein	Energy (kJ per person and day)				
	(g per person and day)	Fat	Fibre	Carbohydrates	Protein	Energy
Cereal products	22	254	88	2240	368	2960
Pastries	3.4	251	9	390	57	710
Meat	43	949	0	0	725	1670
Fish	6.7	200	3	37	114	350
Dairy products, fluids	11	191	0	280	186	660
Dairy products, solids	12	764	0	39	200	1000
Eggs	3.3	88	0	11	56	160

Fats and oils	0.16	1147	0	4	3	1150
Vegetables	2.5	29	28	140	43	240
Fruits	3.0	147	28	670	52	900
Potatoes	2.5	98	20	397	43	560
Sugar and sweets	3.8	791	16	1064	65	1940
Beverages	n.a.	0	0	199	0	200
Sum	112	4910	190	5470	1910	12500
Energydistribution		39E%	1.5E%	44E%	15E%	
MB 2010[1]	*n.a.*					*12500*
Riksmaten adults[2]	*81*	*34E%*	*2.0E%*	*44E%*	*17E%*	*8000*

[1] NFA 2012, [2]Amcoff et al 2012, excluding alcohol (300 kJ per person and day)

Protein. Estimated intake of protein was about 110 grams per person and day (Table 11.1:6). 'Meat', 'cereal products', and 'dairy products' contributed with 75 % of the intake.

11.1.5 Effect of cooking

Traditionally MB analyses in Sweden were made on foods as purchased. However, as food composition might be affected by cooking, a pilot cooking study was made. Cooking experiments are described in chapter 7 and Annex II. Cooking might cause loss of fat due to migration or uptake of fat if fat is added during cooking. Previous studies have shown alterations in fatty acid composition due to oxidation during cooking (e.g. Badiani et al., 2013; Sioen et al., 2006; Bognar, 2002). However, rate of fat oxidation depends on many factors e.g. oxygen exposure, temperature, moisture, number, position and geometry of the double bounds in the fatty acids and presence of anti- and pro-oxidants. Thereby it is difficult to predict how different fatty acids will be affected by cooking. For the MB the aim is not evaluate the fate of individual fatty acids but to determine if cooking has an effect on estimated intakes of fat and fatty acids from the studied food categories. As intakes are estimations with many sources of error e.g. Swedish Board of Agriculture data on production and trade, food choice and analytical measurement error, it is possible that a significant change in concentrations during cooking has no significant effect on the intake estimation of fat and fatty acids.
For nutrients true retention (TR) is commonly used to measure stability during cooking (e.g. Badiani et al., 2013; Bognar, 2002):

$$TR = \frac{\text{content per gram cooked food} \times \text{g cooked food}}{\text{content per gram raw food} \times \text{g raw food}}$$

By using the concept of true retention, weight changes during cooking is accounted for. Whether cooking had an effect on estimated nutrient intake was tested using Wilcoxon's signed rank test with log-transformed true retention as variables.

Table 11.1:7. True retention and effect of cooking on estimated average daily intake of total fat and major fatty acid categories (grams per person)

		Total fat	SFA	MUFA	PUFA
Estimated intakes					
Meat	raw	27	10	13	2.4
	cooked	26	10	12	2.5
Fish	raw	5.5	0.70	2.7	1.6
	cooked	4.6	0.61	2.3	1.2
True retention					
Meat and fish		0.95	0.96	0.95	0.95
N (fatty acids)			10	11	11
P		n.a.	0.006	0.004	0.056

SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids;
n.a. – not applicable. N – indicate number of individual fatty acids detected and included in calculations. Log-transformed quotas of individual fatty acid within each category (e.g. SFA) were used to test whether cooking had an effect on exposure of e.g. SFA.
Complete data set in Annex VI.

Cooking resulted in fat loss in fish and consequently changes in fatty acid composition (Table 11.1:7), which is in line with previous studies (Badiani et al., 2013; Bognar, 2002). Lower fat content explains why significant decreases in true retention were found for saturated-, monounsaturated- and polyunsaturated fatty acids. Hence effects of cooking should preferably be taken into account when analysing fatty acids. Oxidation of unsaturated fatty acids results in oxydimers and polymers with e.g. hydroperoxide.

11.1.6 Benefit and/or risk assessment

In the MB average intake of macronutrients has been estimated. The results should be evaluated keeping in mind that the average intake represents the average *supply* of macronutrients in Sweden, i.e. the MB results are not the true intakes (read more about limitations of the MB in chapter 13).

Energy content in the MB was estimated using analytical data (or data derived from analytical data) on fat, fibre, carbohydrates and protein content. Energy conversion factors were those internationally used i.e. 37 kJ per gram fat, 17 kJ per gram protein and glycaemic carbohydrates, 29 kJ per gram alcohol and 8 kJ per gram fibre (NNR, 2012). Estimated energy content was combined with data on supply of alcohol per capita and day from SBA (12.7 grams per person and day corresponding to 368 kJ, SBA 2016).

Energy supply from the MB (including data on alcohol from SBA) was estimated to 12.9 MJ per person and day (about 3100 kcal). This corresponds to the energy requirement of an adult man with an active lifestyle. However, a limitation with using SBA data on production and trade statistics is overestimation of intakes as food losses and waste are not accounted for (for more details about limitations of the MB see chapter 13). Food loss and waste is by Food and Agriculture Organization (FAO) defined as: Food losses or waste are the masses of food lost or wasted in the part of food chains leading to "edible products going to human consumption" (Gustavsson et al., 2011). In Sweden, total food loss and waste in household, restaurants and stores was estimated to 316 000 tons in 2014 (NFA and Swedish EPA, 2015), corresponding to about 4-5% of the available food supply in Sweden (chapter 10). Food waste is higher for certain food categories, e.g. meat in stores and fruit and vegetables in restaurants, which unfortunately cannot be accounted for when evaluating MB due to limited data on food waste of different food groups in the households. If we assume a 15% overestimation between supply - as assessed using the MB - and energy intake, the average energy intake would be estimated to 10.9 MJ per person and day. This corresponds to an active lifestyle for young women (18-30 y). However, if considering that e.g. children, elderly as well as women and men having a low physical activity have a lower energy requirement the result from the MB indicates that energy supply in Sweden in average is too high to maintain energy balance.

The estimated daily intakes were evaluated using the Nordic Nutrition Recommendations (2012).

Average estimated intakes were in line with recommendations (given in parenthesis) for:

- Total fat (recommendation 25-40 E%): estimated to 38 E%,
- monounsaturated fatty acids (recommendation estimated to 10-20 E%): 15 E%,
- n-3 fatty acids (recommendation >1 E%): estimated to 1 E%
- sum of linoleic and alfa-linolenic acid (recommendation > 3E%): estimated to 4 E% and
- protein (recommendation 10-20 E%): estimated to 15 E%.

Average estimated intakes were *close to* recommendations for:

- Polyunsaturated fatty acids (recommendation 5-10 E%): estimated to 5 E%,
- dietary fibre (recommendation 25-35 g per person and day): estimated to 24 gram
- added sugars (recommendation <10 E%): estimated to 11 E% and
- carbohydrates (recommendation 45-60 E%): estimated to 43 E%

Average estimated intakes were *not* in line with recommendations for:

- Saturated fatty acids (recommendation < 10 E%): estimated to 15 E%.

Fat. Estimated total fat intake was in the upper range of the recommendation. Fat intake was overestimated due to food waste, in particular in the food groups that contributes the most to fat intake e.g. 'fats and oils' and 'meat' (Fig. 11.1:1). By cooking foods, overestimation of fat due to migration may be accounted for. Using cooked foods instead of raw resulted in a total fat intake corresponding to 36 E%. However, this is also an overestimation since e.g. inter-muscular fat in meats such as lamb chops and pork collar might be removed by consumers and non-absorbed oil used for deep frying usually is discarded (for details about sample preparation see chapter 8).

Major fatty acid categories. Recommended intake of saturated fatty acids should be below 10 E%. In the MB study intake of saturated fatty acids was estimated to 15 E% when analysed as raw and 14 E% when analysed as cooked. However, this is most likely also an overestimation as stated above.

Estimated daily intake of monounsaturated and polyunsaturated fatty acids were in line with recommendations, in average 15 E% and 5 E%, respectively. If analysed as cooked estimated intake of monounsaturated fatty acids was 14 E% and polyunsaturated fatty acids 5 E%. Cis-monounsaturated and cis-polyunsaturated fatty acids is recommended to contribute with at least 2/3 of the total fatty acid intake, in the MB study those fatty acids contributed with about 60% of fatty acid intake (Annex IV).

Minor fatty acid categories. Minor fatty acid categories were in line with recommendations even if a slight overestimation of the intake is assumed. The essential linoleic (18:2 n-6) and alfa-linolenic acid (18:3 n-3) is recommended to contribute with at least 3 E%. Estimated contribution was 4 E% when analysed as raw and as cooked.

At least 0.5 E% should be alfa-linolenic acid, this was estimated to 1 E%. When analysed as cooked estimated intake of alfa-linolenic acid was 0.08 E%. Estimated intake of DHA (22:6 n-3) was 190 mg per day. Intake of trans-fatty acids should be as low as possible, estimated intake was 1 gram per person and day.

Carbohydrates

Compared with recommendations (45-60 E%), estimated daily intake of total carbohydrates was in the lower range, about 45 E%.

Dietary fibre

Recommended intake of dietary fibre is 'at least 25-35 gram per day', which is slightly higher than estimated supply in this MB study (24 gram/day). Taking food waste into account might increase the gap between estimated and recommended intake.

The used fibre method underestimate fibre content according to the EU definition (EU regulation 1169/2011) thus it is possible that the average fibre intake was above 25 grams per day. For a subset of legumes and cereals in the Swedish food composition database (n=25) analysed fibre content was in average 30% higher when using the current fibre definition including non-available oligosaccharides. However, for the MB we used the fibre definition according to NNR (2012) to enable comparison with the recommendation

as well as time-trend analysis in estimated fibre intakes. It is important to remember that recommendations for fibre mainly are set using epidemiological evidence based on the fibre definition not including e.g. resistant oligosaccharides and inulin.

Compared with MB 2010 estimated fibre intake is nearly 15 % higher. This might indicate a greater supply of fibre. However, fibre was not analysed in 'sugar and sweets' in 2010 and if this data is excluded the difference between the MB 2010 and the current is only 5 %.

Added sugars

Intake of added sugar should be kept below 10 E%, corresponding to about 60 grams per day. Estimated intake of added sugar was 80-85 grams per day, about 11 E%. This is similar to estimated intake for adults in USA 10 years ago (77 grams per day) (Welsh et al., 2011). Intake estimations of added sugars are biased by the estimation of added sugar content.

Compared to previous MB the pattern of sugars has changed, estimated intake of glucose and fructose has increased (25 %) whereas intake of sucrose has decreased (34 %). This is possibly a consequence of the increased use of other sweeteners than sucrose, e.g. high-fructose syrups.
To summarise, estimated sugar intake is above the recommendation, however, the results also indicate a positive trend in intake of added sugars.

Protein

Estimated energy contribution from protein (15 E%) was well within the recommended range for children and adults between 2-64 years (10-20 E%). For elderly the recommendation is higher (15-20 E%) and for infants and toddlers lower (7-15 E% and 10-15 E%, respectively).

11.1.7 Conclusion

Sweden has a dietary advice 'Try to maintain energy balance by eating just the right amount.' In the MB energy supply has been estimated to about 12.9 MJ/day. This is the energy requirement of an adult man having an active lifestyle. It is, however, important to remember that the energy supply – as assessed using the MB - is not equal to the energy intake in the population. Still, even if the supply is overestimated by 10-20 %, the high energy content in the MB is troublesome as most individuals have a substantially lower energy requirement, e.g. children, elderly and people having a sedentary lifestyle. There are some important limitations with the MB that are important to remember when evaluating the results e.g.: 1) errors associated with uncertainty in per capita consumption; 2) errors associated with food choice and proportions within each food group; 3) measurement errors for determination of contents; 4) rough estimation of food waste/difference between supply and intake. However, despite those limitations the results indicate that the high energy supply from the market basket makes it difficult to maintain energy balance unless having an active lifestyle, which is not the case for the average population (Hansen et al., 2012).

Since 2005 estimated supply of fat and all fatty acid categories has increased. At the same time supply of starch decreased by 15% and supply of sugars decreased slightly.

However, comparison of fat and sugar intake over time must be evaluated with care as other analytical methods are used for those nutrients in the current MB study compared with previous studies.

Analysis of foods as 'ready-to-eat' instead of as purchased resulted in lower estimated intakes of fat and fatty acid categories. Hence effects of cooking should preferably be taken into account when analysing fatty acids in MB.

To summarise estimated intakes of fat, monounsaturated fatty acids, n-3 fatty acids and protein were in line with NNR (2012) whereas supply of saturated fatty acids and added sugar was above recommendations and polyunsaturated fatty acids and dietary fibre just below recommendations.

11.2 Vitamins

11.2.1 Background

For benefit assessment, data on vitamins are of importance. In the previous MB vitamin D_3 was included, in this MB vitamin E, vitamin K and folate are determined for the first time.

11.2.2 Chemical analysis

Vitamin D_3 was determined in cereal products, pastries, meat, fish, dairy products, eggs, and fats and oils. The published method used is accredited and validated in an NMKL collaborative study (Staffas and Nyman, 2003). Vitamin D_2 is used as internal standard. The sample is extracted with n-heptane after addition of internal standard and saponification. After evaporation the sample extract is purified with straight phase HPLC using a silica column. Quantitative determination is done by reversed phase HPLC (C-18) with UV detection. The content of vitamin D_3 is calculated with the internal standard as reference. The LOD is 0.1 µg/100 g, except for dairy products where the LOD is 0.01 µg/100 g.

Vitamin E was determined in the food categories cereal products, pastries, meat, fish, dairy products, eggs, and fats and oils. The test portion is saponified after addition of ethanol, potassium hydroxide and ascorbic acid. The hydrolysate is extracted on a Chem Elut-column, containing silica particles, using cyclohexane as eluent. The final extract is analysed on HPLC with simultaneous detection of retinol, using a UV-detector, and tocopherols, using a fluorescence detector.The limit of quanitification is 0.04 mg/100 g.

Vitamin K was determined in cereal products, pastries, meat, fish, dairy products, eggs, and fats and oils. The sample is mixed with 70% ethanol and the fatty soluble components are extracted with heptane during reflux cooking. The heptane phase is concentrated and the final extract is analysed by reversed phase HPLC with a fluorescence detector. A reduction column filled with zinc powder is used, and therefore vitamin K can be detected in low concentrations. The limit of quanitification is 1 µg/100 g.

Total folate was deterimined in the food categories cereal products, pastries, meat, fish, dairy products, eggs, vegetables, fruits, potatoes and sugar and sweets, in September 2016. The method used was an accredited European standard method (SS-EN 14131:2004 Foodstuffs – Determination of folate by microbiological assay). Heat and tri-enzymatic sample extraction was performed in phosphate buffer. Determinitation of folate was performed by determining the growth of the lactic acid bacteria *L. casei* by spectrophotometric measurement of the turbidity.

11.2.3 Analytical results

Concentrations of vitamins are presented in Table 11.2:1. This MB survey is the first to include vitamin E, vitamin K and folate for determination; vitamin E from alpha-tocopherol, vitamin K as the sum of vitamin K_1 (phylloquinone) and K_2 (menaquinone-4) and folate as total amount.

When possible nutrient content was evaluated using the EU regulation for nutrient claims (EU regulation 1924/2006). Nutrient claims are not intended for food groups. Hence the use of the definitions for claims in the MB should only be considered as guidance to when a nutrient in average is present in a food group in an amount considered significant. Furthermore, individual food items might be 'source of' or 'high' in a nutrient although present in food groups having an average content below the requirement for that nutrient.

Significant amount of vitamins correspond to 15% of the nutrient reference values (RDA), (EU regulation on food information, (EU regulation 1169/2011).

The NFA determine most vitamins for the food composition database. Whereas samples for the MB are prepared as composite samples of several different foods within a food group, samples for the food composition database are prepared of several products of one single food. However, it was possible to compare the MB results for 'eggs' with corresponding composite samples recently analysed for the food compostion database and the results showed good agreement (Gard et al., 2010). Food composition data for eggs in 2008, average of conventional and organic were for vitamin D_3 (1.45 µg/100 g) vitamin E (5.75 µg/100 g), vitamin K (27.1 µg/100 g) and folate (84.7 µg/100 g).

Vitamin D_3. The highest content was found in 'fats and oils' (10 µg/100 g), followed by 'fish' (3.25 µg /100 g) and 'eggs' (1.55 µg /100 g). Compared with the RDA of 5 µg/100g, these amounts are to be considered as significant.

Vitamin E. Also for vitamin E the highest content was found in 'fats and oils' (10.9 mg/100 g), 'eggs' (4.15 mg/100 g) and 'fish' (2.78 mg/100 g). In addition a high content was also found in 'pastries' (2.30 mg/100 g). Compared with the RDA of 12 µg/100g these amounts are to be considered as significant.

Vitamin K. Also for vitamin K the highest content was found in the 'fats' group (47.3 µg/100 g) and in 'eggs' (30.7 µg/100 g). In addition, high contents were found in 'vegetables' (26.3 µg/100 g) and 'meat' (16.6 µg/100 g). Compared with the RDA of 75 µg/100g these amounts are to be considered as significant.

Folate. For folate the highest content was found in 'eggs' (90.8 µg/100 g). In addition, fairly high content were found in the 'cereal products' (28.9 µg/100 g). however,

compared with the RDA of 200 µg folic acid/100g only the amount in eggs is to be considered as significant.

Table 11.2:1. Concentrations of vitamins in the food groups (unit/100 g).

Food Category	Vitamin D_3 µg	Vitamin E mg	Vitamin K µg	Folate µg
Cereal products	<0.1	0.695	2.01	28.9
Pastries	<0.1	2.30	9.19	19.0
Meat	0.14	0.409	16.6	3.62
subgroup processed meats	0.14	0.381	9.90	5.74
Fish	3.25	2.78	7.11	6.39
Dairy products, fluids	0.30	0.045	0.40	5.56
Dairy product, solids	<0.1	0.556	9.33	15.4
Eggs	1.55	4.15	30.7	90.8
Fats	10.0	10.9	47.3	n.a.
Vegetables	n.a	0.408	26.3	9.64
Fruits	n.a	0.497	3.41	6.62
Potatoes	n.a	0.186	1.13	12.6
Sugar and sweets	n.a	1.62	7.21	10.6
Beverages	n.a	0.032	n.a	n.a.

n.a. = not analysed

11.2.4 Exposure estimation, time trends

Estimated average daily intake of minerals are summarised in Table 11.2:2.

The food category ‘fats and oils’ is important for the contribution to the estimated intake of the fat-soluble vitamins; vitamin D_3 (64 %), vitamin E (28 %) and vitamin K (12 %). The category ‘dairy products, solid’ is important for the contribution of both vitamin K (16 %) and folate (21%). Other important sources; for vitamin D_3 ‘fish’ (21 %), for vitamin K ‘vegetables’ (28 %) and ‘meat’ (19 %) and for folate ‘cereal products’ (28 %) and ‘eggs’ (11 %).

The time trend for vitamin D_3 extends to one previous MB and shows an increase in the estimated intake from 6.1 µg to 7.0 µg per person and day. Vitamin E, vitamin K and folate are determined for the first time and time trends can be estimated in future MB studies.

Table 11.2:2. Average daily per capita intake of vitamins.

Food Category	Vitamin D_3 µg	Vitamin E mg	Vitamin K µg	Folate µg
Cereal products	n.a.	1.59	4.60	66.2
Pastries	n.a.	1.12	4.46	9.21
Meat	0.297	0.867	35.2	7.68
subgroup processed meats	0.079	0.216	5.61	3.26
Fish	1.49	1.27	3.25	2.92
Dairy products, liquids	0.238	0.036	0.318	4.42
Dairy products, solids	n.a.	1.80	30.2	49.8
Eggs	0.429	1.15	8.50	25.1
Fats and oils	4.49	4.90	21.3	
Vegetables	n.a.	0.806	52.0	19.0
Fruits	n.a.	1.16	7.95	15.4
Potatoes	n.a.	0.235	1.43	15.9
Sugar and sweets	n.a.	2.04	9.07	13.3
Beverages	n.a.	0.10	n.a.	n.a.
Sum	7.02	17.3	184	232
MB 2010[1]	6.1	n.d.	n.d.	n.d.
Riksmaten adults[2]	7.0	12.4	n.d.	259

n.a. – not analysed;. n.d. – not determined. [1]NFA, 2012; [2]Amcoff et al 2012

11.2.5 Effect of cooking

Traditionally MB analyses in Sweden were made on foods as purchased. However, since food composition might be affected by cooking, a pilot cooking study was made.Weight changes during cooking were accounted for.

The vitamin content in this pilot study was higher in the prepared foods (Table 11.2:3) which might indicate that preparation of the foods has made the vitamins more available. Previous determination of vitamins in potatoes also showed a significant increase in vitamin E after boiling (Öhrvik et al, 2010). However, this might be an effect from deterioration during sample preparation. The homogenisation of the foods makes the vitamins more exposed to oxidisation, both by air and by enzymes present in foods. In cooked foods the enzymes are denaturated, which might lead to a slower rate of oxidisation and thereby a higher vitamin content.

The changes in content due to cooking are apparently large (3 – 260 %) within the studied food groups, but has a smaller impact on the total per capita intake (3 – 5 %). However, this needs to be considered when comparing vitamin data from MB studies with data fromTDS.

In order to establish data for true retention for the vitamins in this study, more data are needed. Possible differences due to deterioration during sample preparation should also be further investigated.

Table 11.2:3. Effect of cooking on estimated average daily intake of vitamins (data adjusted for weight losses due to cooking).

		Vitamin D_3 µg	Vitamin E mg	Vitamin K µg	Folate µg
Estimated intakes					
Meat	raw	0.297	0.56	33.4	6.85
	cooked	0.346	1.45	38.4	11.0
Fish	Raw	1.36	1.19	2.66	1.80
	cooked	1.60	1.22	3.64	4.69

11.2.6 Benefit and/or risk assessment

The estimated intake of vitamin D_3 and folate is in good agreement with the average intake and vitamin E was higher than in the recent national food survey on adults, Riksmaten 2010-11 (Amcoff et al., 2012). In this survey, folate intake and blood status in the Swedish population was recently evaluated (Öhrvik et al., 2016b). The estimated dietary intake of folate was found to be well above average requirement for folate, which was reflected in the biomarker status. Few of the sampled population in the study had low concentration of erythrocyte folate.

Although the estimated intake of vitamin D_3 is in good agreement with the average intake in Riksmaten 2010-11 (Amcoff et al., 2012), the same survey showed that several individuals have intakes below the average requirement of vitamin D. A range of health benefits of vitamin D have been suggested and therefore during recent years several countries, including the Nordic countries, have increased the recommended intake of vitamin D (NNR, 2012). In Sweden, an increased fortification with higher levels and more products are planned. However, some products have already increased the content of vitamin D which might be reflected in the higher estimated intake.

For vitamin K, no recommendations in NNR 2012 are given due to lack of sufficient evidence. However, a provisional recommended intake of 1 µg/kg body weight per day is given for both children and adults. The estimated intake of vitamin K was higher than the provisional recommended intake of 76.6 µg for adults.

11.2.7 Conclusion

Average estimated intakes of vitamin D_3 and folate were close to average requirement while the intake of vitamin E and vitamin K was higher. Differences in vitamin data due to cooking should be consider when comparing MB studies (foods as purchased) with data from TDS (as eaten).

11.3 Essential mineral elements

11.3.1 Background

There are 112 known naturally occurring elements of which 21 are considered essential according to present knowledge. Of those the content of the following have been determined in the present MB study: iron (Fe), potassium (K), sodium (Na), phosphorus (P), zinc (Zn), chromium (Cr), copper (Cu), iodine (I), manganese (Mn), molybdenum (Mo) and selenium (Se). Cobalt (Co) is not generally considered as essential, however as cobalt is required as a component in the vitamin B12 molecule it was included in the MB analyses.

11.3.2 Chemical analysis

The analysis of total concentrations of essential (and non-essential) elements in the samples were performed by ALS Scandinavia AB, Luleå by High Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP-MS). In order to achieve lowest possible detection limits and to avoid contamination risks associated with additional homogenization of samples, sample amount was increased to >1 g per digestion. Weighing was done directly into acid washed, 50 ml plastic vessels. After addition of concentrated nitric acid (10:1, v/m), samples were left to react overnight followed by graphite hot-block digestion (105˚C, 2 hours). After cooling, volume of transparent digests was adjusted to 40 ml with MQ-water. Prior to analysis stage, samples were further diluted to provide total dilution factor of approximately 100 and nitric acid concentration of 1.4 M. A set of preparation blanks, duplicate samples and control materials was prepared alongside with samples.

Concentration of elements of interest were measured by HR-ICP-MS (ELEMENT XR, Thermo Scientific), using combination of internal standardization (In and Lu added to all solutions at 1 µg/l) and external calibration with set of standards matching sample digests in acid strength. All-PFA introduction system, high sensitivity X-type skimmer cone and FAST autosampler (excluding contact of sample digests with peristaltic pump tubing) allows instrumental sensitivity in excess of 2000 counts/s for 1 ng/l Indium-115. In order to minimize matrix effects and to increase sensitivity of arsenic, selenium and cadmium, the ICP was operated with methane addition. Spectral interferences were either avoided using high resolution settings of MS or mathematically corrected. Method detection limits (defined as 3 times the standard deviation of analyte concentrations measured in a set of preparation blanks) is presented in Table 11.3.1 and the measurement uncertainty is below 15% depending on the element and its level of concentration. The method is based on the accredited method that ALS Scandinavia AB use in their routine work for analysis of biological matrices (Engström, 2004; Rodushkin, 2008). 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 11.3:1 Limits of detection (LOD, 3*std for blank, n=9) for essential elements measured by high resolution-ICP-MS by ALS Scandinavia AB, Luleå, Sweden.

Type of sample	Limit of detection, µg/kg*											
	Co	Cr	Cu	Fe	I	K	Mn	Mo	Na	P	Se	Zn
Solid	2.6	5	5	27	23	3250	6	0.7	686	498	6	49
Liquid	1.3	2.6	2.6	14	12	1630	2.8	0.4	343	249	3	25

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

11.3.3 Analytical results

Mineral content in the food categories are presented in Tables 11.3:2 and 11.3:3 (complete data set presented in Annex VII). When possible nutrient content was evaluated using the EU regulation for nutrient claims (EU regulation 1924/2006). Nutrient claims are not intended for food groups. Hence the use of the definitions for claims in the MB should only be considered as guidance to when a nutrient in average is present in a food group in an amount considered significant. Furthermore, individual food items might be 'source of' or 'high' in a nutrient although present in food groups having an average content below the requirement for that nutrient.

Significant amount of minerals correspond to 15% of the nutrient reference values according to EU regulation on food information (EU regulation 1169/2011).

Iron. No food category contained more than 15% of the nutrient reference value for iron in average.

Potassium. 'Potatoes' and 'meat' contained more than 15% of the nutrient reference value for potassium in average.

Sodium. The highest sodium concentrations were found in 'cured processed meat' followed by 'fish'. 'Cured processed meat' contained in average about 850 mg sodium per 100 g, which corresponds to about 2.1 g salt per 100 g.

A claim that a food is low in sodium/salt, may only be made where the product contains less than 0.12 g of sodium per 100 g (Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods). For the analysed food categories the following contained less than 0.12 g of sodium per 100 g: 'dairy products-liquid', 'vegetables', 'fruits', 'potatoes' and 'beverages'.

Phosphorus. 'Cereal products', 'pastries' and 'pizza, pirogue', 'meat', 'cured processed meat', 'fish', 'dairy products-solid' and 'eggs' contained more than 15% of the nutrient reference value for phosphorus in average.

Zinc. 'Meat' and 'dairy products-solid' contained more than 15% of the nutrient reference value for zinc in average.

Cobalt. No nutrient reference value is set for cobalt.

Chromium. 'Pastries' and 'cured processed meat' contained more than 15% of the nutrient reference value for chromium in average.

Copper. 'Cereal products' contained more than 15% of the nutrient reference value for copper in average.

Iodine. 'Fish' and 'eggs' contained significant amounts of iodine in average.

Manganese. 'Cereal products', 'pastries' and 'pizza, pirogue' contained more than 15% of the nutrient reference value for manganese in average.

Molybdenum. 'Cereal products', 'pastries' and 'pizza, pirogue' contained more than 15% of the nutrient reference value for molybdenum in average.

Selenium. 'Eggs', 'fish' and 'meat' contained more than 15% of the nutrient reference value for selenium in average.

Table 11.3:2 Content of essential mineral elements in mg/100 g (N=5).

Food Group		**Concentration in mg/100 g**				
		Fe	**K**	**Na**	**P**	**Zn**
Cereal products	Mean	1.59	253	283	164	1.29
	Median	1.54	242	295	168	1.31
	Min	1.41	225	257	133	1.13
	Max	1.98	282	301	184	1.45
Pastries	Mean	1.02	189	370	133	0.80
	Median	1.05	187	374	137	0.80
	Min	0.88	175	354	117	0.74
	Max	1.13	201	392	150	0.87
Pizza, pirogue	Mean	0.85	232	463	182	1.33
	Median	0.89	225	451	180	1.31
	Min	0.71	202	417	140	1.00
	Max	0.97	262	529	247	1.72
Meat	Mean	1.16	312	370	180	1.93
	Median	1.09	305	381	168	1.83
	Min	1.01	297	313	152	1.67
	Max	1.47	340	404	225	2.41
Subgroup processed meat	Mean	1.26	225	872	140	1.33
	Median	1.24	217	858	142	1.33
	Min	1.20	180	846	119	1.22
	Max	1.42	278	914	159	1.44
Fish	Mean	0.31	248	564	162	0.44
	Median	0.31	247	545	165	0.45

Food Group		Concentration in mg/100 g				
		Fe	**K**	**Na**	**P**	**Zn**
	Min	0.28	238	508	148	0.39
	Max	0.33	265	628	170	0.51
Dairy products, solids	Mean	0.09	94.1	371	317	1.79
	Median	0.09	95.3	348	319	1.80
	Min	0.08	85.2	332	292	1.60
	Max	0.10	97.7	465	354	1.93
Dairy products, liquids	Mean	0.02	168	35.4	98.4	0.36
	Median	0.02	169	35.3	98.3	0.36
	Min	0.02	159	32.5	92.1	0.34
	Max	0.02	175	38.4	103	0.37
Eggs	Mean	1.88	147	132	197	1.22
	Median	1.87	146	132	199	1.25
	Min	1.80	141	128	186	1.15
	Max	1.95	152	137	205	1.29
Fats and oils	Mean	0.04	33.8	413	11.6	0.04
	Median	0.04	32.5	407	11.2	0.04
	Min	0.03	30.1	394	9.51	0.03
	Max	0.06	38.7	447	15.9	0.06
Vegetables	Mean	0.31	204	51.2	29.2	0.19
	Median	0.31	212	46.8	28.9	0.20
	Min	0.27	176	41.2	26.9	0.18
	Max	0.37	234	74.6	31.9	0.21
Fruits	Mean	0.25	213	12.1	26.7	0.15
	Median	0.23	218	10.8	26.7	0.14
	Min	0.18	193	2.73	24.4	0.13
	Max	0.34	224	19.9	28.7	0.17
Potatoes	Mean	0.41	431	26.8	51.0	0.26
	Median	0.43	428	27.4	48.9	0.26
	Min	0.31	399	19.5	47.9	0.22
	Max	0.46	467	35.1	59.1	0.30
Sugar and sweets	Mean	1.54	256	269	71.0	0.39
	Median	1.46	255	267	74.2	0.38
	Min	1.32	240	233	52.5	0.32
	Max	1.85	270	306	77.4	0.43
Beverages	Mean	0.004	9.47	3.92	6.80	0.003
	Median	0.004	9.90	3.93	7.07	0.003
	Min	0.002	8.01	3.26	5.09	0.003
	Max	0.005	10.3	4.61	8.51	0.008

Table 11.3:3. Content of essential mineral elements in µg/100 g (N=5).

Food Group		Concentration in µg/100 g						
		Co	**Cr**	**Cu**	**I**	**Mn**	**Mo**	**Se**
Cereal products	Mean	1.1	1.6	202	5.1	1055	41	3.8
	Median	1.0	1.5	198	4.6	1047	40	3.4
	Min	0.9	1.4	188	2.5	968	38	2.9
	Max	1.6	2.3	226	8.2	1177	46	5.3
Pastries	Mean	1.2	6.1	120	2.8	490	15	3.6
	Median	1.2	5.6	121	2.8	446	15	3.6
	Min	0.9	3.6	107	2.4	417	14	2.8
	Max	1.4	9.8	139	3.5	592	16	4.3
Subgroup	Mean	0.8	3.5	117	3.3	412	14	5.3
Pizza, pirogue	Median	0.7	3.5	116	3.1	366	14	5.2
	Min	0.6	2.4	99	2.7	300	12	3.2
	Max	1.2	4.4	140	4.2	643	17	8.1
Meat	Mean	< 0.3	3.1	66	2.2	35	5	8.9
	Median	< 0.3	2.7	62	1.2	32	5	8.2
	Min	< 0.3	2.2	56	< 2.3	30	3	6.9
	Max	< 0.3	4.9	83	4.2	44	7	14
Subgroup	Mean	< 0.3	7.5	65	< 2.3	44	4	7.0
Processed meats	Median	< 0.3	8.4	62	< 2.3	38	4	6.9
	Min	< 0.3	3.1	58	< 2.3	32	4	6.1
	Max	< 0.3	9.4	86	< 2.3	60	5	8.4
Fish	Mean	< 0.3	1.4	48	46	37	1	20
	Median	< 0.3	1.3	45	41	35	1	20
	Min	< 0.3	0.8	41	37	27	1	16
	Max	0.4	2.3	62	68	55	1	22
Dairy products, solids	Mean	< 0.3	0.8	28	10	13	7.5	7.3
	Median	< 0.3	0.8	28	8.9	12	6.9	7.8
	Min	< 0.3	0.7	23	8.6	11	6.8	5.3
	Max	< 0.3	1.0	32	12	16	9.0	8.1
Dairy products, liquids	Mean	< 0.1	0.3	6.9	6.7	6.6	4.5	2.1
	Median	< 0.1	0.3	6.5	6.2	6.3	4.4	2.3
	Min	< 0.1	< 0.3	6.0	5.4	4.7	3.4	1.0
	Max	< 0.1	0.4	8.1	9.0	7.8	5.5	2.4
Eggs	Mean	< 0.3	< 0.3	60	28	53	6.0	22
	Median	< 0.3	< 0.3	59	26	51	5.3	20
	Min	< 0.3	< 0.3	58	21	46	3.3	18

	Max	< 0.3	0.5	64	34	58	10	27
Fats and oils	Mean	< 0.3	0.7	2.8	2.3	2.5	1.3	0.7
	Median	< 0.3	0.7	1.7	2.3	2.4	1.3	0.3
	Min	< 0.3	0.6	1.3	2.3	1.8	1.1	< 0.6
	Max	< 0.3	1.1	7.5	2.4	3.3	1.5	1.6
Vegetables	Mean	0.5	1.6	44	4.3	132	7.6	0.6
	Median	0.4	1.6	45	3.2	125	7.3	0.6
	Min	0.3	1.4	41	3.0	118	5.8	< 0.6
	Max	0.6	1.8	49	6.7	168	8.9	0.8
Fruits	Mean	0.4	1.3	82	3.4	267	3.4	0.4
	Median	0.3	1.3	78	3.1	241	3.9	0.3
	Min	0.3	1.2	71	3.1	160	1.9	< 0.6
	Max	0.7	1.4	106	4.5	366	4.6	0.8
Potatoes	Mean	0.6	1.0	89	1.4	122	5.9	5
	Median	0.5	0.9	88	1.4	120	4.7	3
	Min	0.5	0.8	67	< 2.3	114	3.8	< 0.6
	Max	0.7	1.2	114	2.5	133	7.1	1.0
Sugar and sweets	Mean	4.2	14	174	2.7	285	5.2	2.9
	Median	4.0	14	168	2.9	249	5.4	2.8
	Min	3.8	10	147	2.1	225	4.6	1.3
	Max	4.8	20	199	2.9	462	5.5	4.8
Beverages	Mean	< 0.1	0.4	4	< 1.2	1	0.2	< 0.3
	Median	< 0.1	0.4	4	< 1.2	1	0.2	< 0.3
	Min	< 0.1	0.3	2	< 1.2	1	0.1	< 0.3
	Max	< 0.1	0.5	7	< 1.2	1	0.2	< 0.3

< indicates a value belowLOD, e.g. 0.1 for Co in beverages.

11.3.4 Exposure estimation, time trends

Estimated average daily intake of minerals are summarised in Table 11.3:4. Contribution of each food group to estimated intake of minerals is illustrated in Fig. 11.3:1. Changes in estimated intake of minerals since 1999 is illustrated in Fig. 11.3:2.

Some food groups are particularly important for mineral supply, i.e. 'cereal products', 'meat', 'fish', 'dairy products' and 'sugar and sweets' each contributing with at least 20% of estimated intake of one or several minerals (Figure 11.3:1). 'Cereal products' contribute with at least 20% of estimated intake of all analysed minerals except for potassium, chromium, iodine and selenium.

For most minerals no clear time-trend was found, changes between initial measurement (1999) and MB 2015 was 20% or below (Figure 11.3:2). However, for iodine there has been a continuous decrease in estimated intake since 1999 whereas for chromium and selenium there has been an increase in estimated intake since 1999.

Iron. Estimated daily intake of iron was the same as in MB 2010, i.e. 11 mg per person (Table 11.3:3) and close to the results from the dietary survey Riksmaten adults 2010-2011 (10.4 mg, Amcoff et al 2012). Main contributors to estimated iron intake were 'cereals' (32%) and 'meats' (22%).

Potassium. Estimated daily intake of potassium was 3.9 g per person and day (Table 11.3:3), which was substantially higher than the results from the dietary survey Riksmaten adults 2010-2011 (3.1 g, Amcoff et al 2012). A possible explanation might be that potassium is commonly used in many additives (e.g. E202, E212, E224, E228, E249, E253, E283, E402, E501, E508, E515, E522, E525, E536, E555, E577). Although TDS and MB might overestimate the intake of all food components as food waste is not accounted for, an advantage regarding potassium, compared to dietary surveys using food composition databases, is that all potassium analyses are up-to-date and measured by the same method. Main contributors to estimated potassium intake were 'meats' (17%), 'dairy products' (16%), 'cereals' (15%) and 'potatoes' (14%).

Sodium. Estimated daily intake of sodium was 3 g per person (Table 11.3:3), corresponding to about 7.5 grams of salt. However, as household salt is not included in the MB sodium intake is underestimated. The main sources of sodium were: 'cereals' (21 %), followed by 'cured processed meat' (16 %), 'dairy products solid' (14 %) and 'sugar and sweets' (11 %).

Estimated daily sodium intake was 280 mg lower per capita than estimated in MB 2010 (3010 versus 3290 mg/day). This was mainly due to lower contribution from 'meat', estimated to 1020 mg/day in 2010 and to 780 mg/day in the current MB, and 'fish', estimated to 340 mg/day in 2010 and to 260 mg/day in the current MB. As sodium content in non-processed fish and meat is low, the results indicate that sodium content in fish products and cured and processed meats have decreased.

Phosphorus. Estimated daily intake of phosphorus was 1.8 g per person and day (Table 11.3:1), which was substantially higher than the results from the dietary survey Riksmaten adults 2010-2011 (1.4 g, Amcoff et al 2012). A possible explanation might be that phosphorus is commonly used in many additives (e.g. E450, E451, E452, E1410, E1412, E1413, E1414, E1442). Although TDS and MB might overestimate the intake of all food components as food waste is not accounted for, an advantage regarding phosphorus, compared to dietary surveys using food composition databases, is that all phosphorus analyses are up-to-date and measured by the same method. Main contributors to estimated phosphorus intake were 'dairy products' (31%), 'meats' (21%) and 'cereals' (21%).

Zinc. Estimated daily intake of zinc was 12 mg per person and day (Table 11.3:3), which was similar as MB 2010 and close to the results from the dietary survey Riksmaten adults 2010-2011 (11 mg, Amcoff et al 2012). Main contributors to estimated zinc intake were 'meats' (34%), 'cereals' (24%) and 'dairy products' (21%).

Manganese. Estimated daily intake of manganese was 4.2 mg per person and day (Table 11.3:4), which was close to the results from MB 2010 (4.0 mg). Main contributor to estimated manganese intake was 'cereals' (57%).

Copper. Estimated daily intake of copper was 1.4 mg per person and day (Table 11.3:4), which was close to the results from MB 2010 (1.3 mg). Main contributors to estimated manganese intake were 'cereals' (33%), 'sugar and sweets' (16%) and 'fruits' (14%).

Table 11.3:4. Average daily per capita intake of essential minerals (mg)

Food group	Fe	K	Na	P	Zn	Mn	Cu
Cereal products	3.6	580	650	380	3.0	2.4	0.46
Pastries	0.49	92	180	64	0.39	0.24	0.06
Subgroup pizza pirogue	0.16	44	89	35	0.26	0.08	0.02
Meat	2.5	660	780	380	4.1	0.07	0.14
Subgroup processed meats	0.72	130	500	79	0.75	0.02	0.04
Fish	0.14	110	260	74	0.20	0.02	0.02
Dairy products, fluids	0.07	540	110	320	1.2	0.02	0.02
Dairy products, solids	0.07	75	300	250	1.4	0.01	0.02
Eggs	0.52	41	36	54	0.34	0.01	0.02
Fats and oils	0.02	15	190	5	0.02	0	0
Vegetables	0.61	400	100	58	0.38	0.26	0.09
Fruits	0.57	500	28	62	0.34	0.62	0.19
Potatoes	0.51	540	34	64	0.33	0.15	0.11
Sugar and sweets	1.9	320	340	89	0.49	0.36	0.22
Beverages	0.01	30	12	21	0.01	0	0.01
Sum	11	3900	3000	1800	12	4.2	1.4
MB 2010[1]	*11*	*n.a.*	*3300*	*n.a.*	*12*	*n.a.*	*1.3*
Riksmaten adults[2]	*10*	*3100*	*3100*	*1400*	*11*	*n.a.*	*n.a.*

Estimated intakes below 0.005 grams per day and person are set to 0; n.a.. – not analysed
[1]NFA, 2012; [2]Amcoff et al 2012

Cobalt. Estimated daily intake of cobalt was 11 µg per person and day (Table 11.3:4), which was similar as in MB 2010. Main contributors to estimated cobalt intake were 'sugar and sweets' (48%) and 'cereals' (23%).

Chromium. Estimated daily intake of chromium was 41 µg per person and day (Table 11.3:4), which was close to the results from the MB 2010 (38 µg). Main contributors to estimated chromium intake were 'sugar and sweets' (41%) and 'meats' (16%).

Iodine. Iodine intake has continuously decreased since 1999 (Fig. 11.3:2), which is troublesome. Compared to the latest MB study (2010) contribution from 'sugar and sweets' (-16 µg), 'fish' (-10 µg), 'meat' (-8 µg) and 'dairy products' (-5 µg) was lower (Table 11.3:5). The lower contribution from 'sugar and sweets' might indicate a lower use of iodine fortified salt in salty products within this category or it may be a result of food choice during sampling. The lower iodine content in 'meat' and 'dairy products' might partly be a result of the opinion from EFSA (2013) proposing a reduction in the iodine upper level for lactating ruminants from 5 to 2 mg/kg complete feed. Iodine supplementation of feed is necessary to meet the iodine requirements of food-producing

animals and the iodine content in the feed is known as the most important factor affecting iodine content of milk (Flachowsky et al., 2014). Other factors that might have reduced iodine content in 'meat' and 'dairy products' are e.g. the increased use of rapeseed and other *Brassica* species containing glucosinolates in the feed. Flachowsky et al. (2014) have summarised all factors affecting iodine content in milk. That no iodine was found in cured and processed meat products indicate that the main producers of cured and processed meats do not use iodised salt as encouraged by the National Food Agency in Sweden (www.slv.se). For 'fish' the decrease of iodine was probably also a consequence of the feed, since farmed fish constitutes an increasing proportion of our fish intake. Recent (2015/2016) analysis of frozen Norwegian salmon bought in Nordic countries resulted in iodine content from less than 6 µg/100 g up to 9 µg/100 g (Pastell et al., 2016). Those values are in the lower range compared with previous measurements on iodine content in salmon, e.g. Nifes (© NIFES 2005) found in average 16 µg/100 g (range 3-47, n=47) in farmed salmon in 2005. Increased use of plant-based feed and/or reduced iodine supplementation might have reduced content in the fish flesh.

Iodine contribution from 'fruits' increased (+6 µg). We might only speculate about the origin, possibly from sodium alginate used as a thickener in e.g. jam.

The estimated iodine intake is underestimated as iodized fortified household salt is not included in the study. However, time trends should not be affected by this probable underestimation, as sampling methods have been the same since the MB 1999.

Molybdenum. Estimated daily intake of molybdenum was 172 µg per person and day (Table 11.3:5), which was slightly higher than the results from the MB 2010 (157 µg). Main contributor to estimated molybdenum intake was 'cereals' (55%).

Selenium. Estimated daily intake of selenium was 62 µg per person (Table 11.3:5) and has increased with 10 µg per person and day since 2010 (Figure 11.3:2). Compared to the latest market basket study (2010) estimated intakes of the main selenium contributors has changed markedly, selenium intake from 'cereal products' (+73%), eggs (+58%), 'dairy products' (+41%) and 'meat' (+40%) was higher whereas contribution from 'fish' (-47%) was lower. For 'fish' the decrease of selenium was probably a consequence of the feed, since farmed fish constitutes an increaseing proportion of our fish intake. Lower proportion of marine feed has been shown to reduce selenium content in fish (Betancor et al., 2016).

To our knowledge, there has not been any increases in selenium addition to feed since 2010. However, several nutritional feed additives containing selenised yeast has by EFSA been considered safe and effective sources of selenium (e.g. Selemax and SelenoSource AF 2000). Thereby one of the explanations might be that use of selenised yeast might have increased among Swedish feed producers. Compared to traditionally used inorganic selenium (e.g. sodium-selenite) the dominating selenium compound in selenised yeast (i.e. selenomethionine) has greater bioavavilability, which might partly explain why selenium content has increased in e.g. meat.

Table 11.3:5. Average daily per capita intake of essential minerals (µg)

Food group	Co	Cr	I	Mo	Se
Cereal products	2.5	3.7	12	94	8.8
Pastries	0.57	2.9	1.4	7.3	1.7
Subgroup pizza pirogue	0.15	0.68	0.64	2.7	1.0
Meat	0	6.5	3.3	10	19
Subgroup processed meats	0	4.2	0	2.4	4.0
Fish	0.06	0.65	21	0.52	8.9
Dairy products, fluids	0	0.65	22	15	6.6
Dairy products, solids	0	0.53	7.7	6.0	5.8
Eggs	0	0.03	7.7	1.7	6.0
Fats and oils	0	0.28	0.42	0.58	0.22
Vegetables	0.90	3.2	5.1	15	0.86
Fruits	1.0	3.0	7.9	8.0	0.36
Potatoes	0.71	1.2	0.5	7.4	0.30
Sugar and sweets	5.3	17	3.5	6.6	3.6
Beverages	0	1.2	0	0.55	0
Sum	11	41	92	170	62
MB 2010[1]	*11*	*38*	*126*	*157*	*52*
Riksmaten adults[2]	*n.d.*	*n.d.*	*n.d.*	*n.d.*	*46*

Estimated intakes below 0.005 grams per day and person are set to 0.
[1]NFA, 2012; [2]Amcoff et al 2012

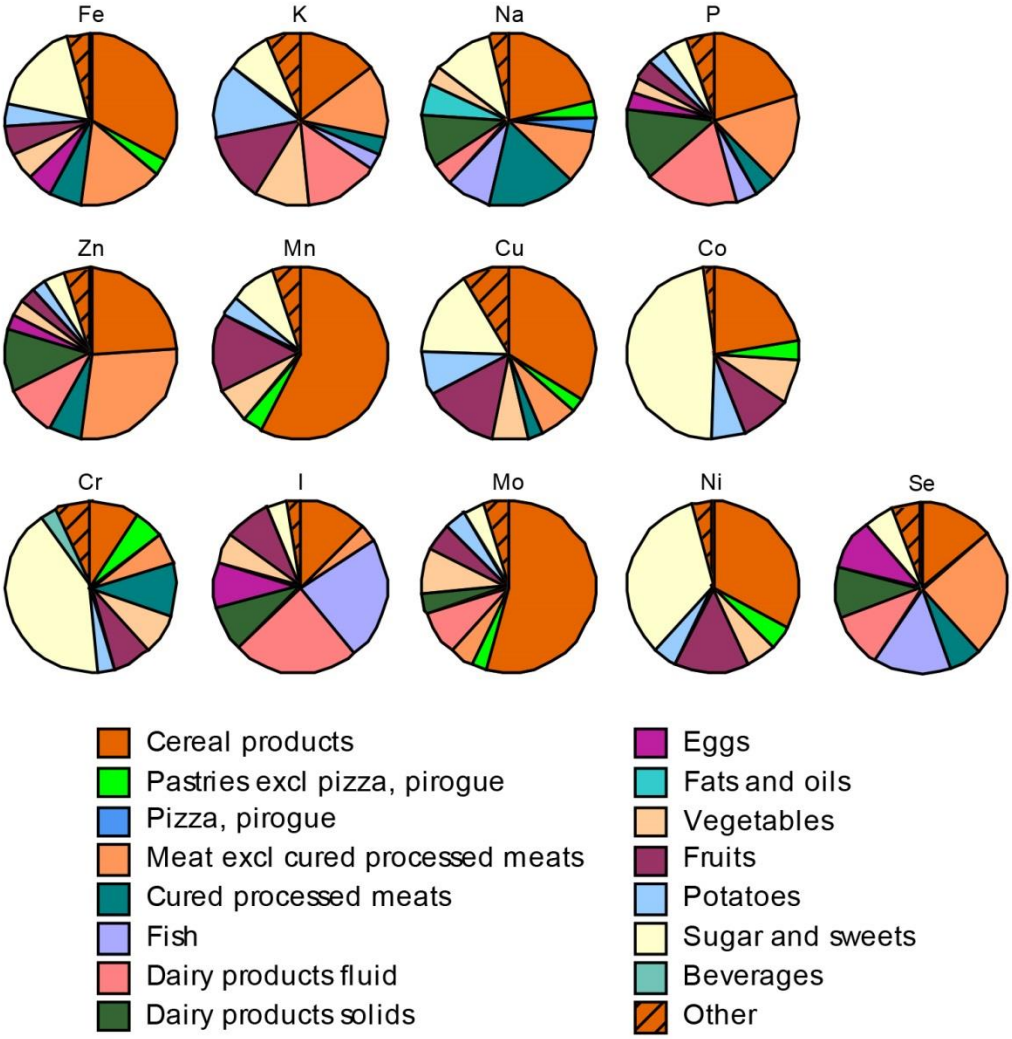


Figure 11.3:1. Percentage contribution of essential minerals from different food groups. Food groups contributing with less than 2.5% are summarised as 'Other'.

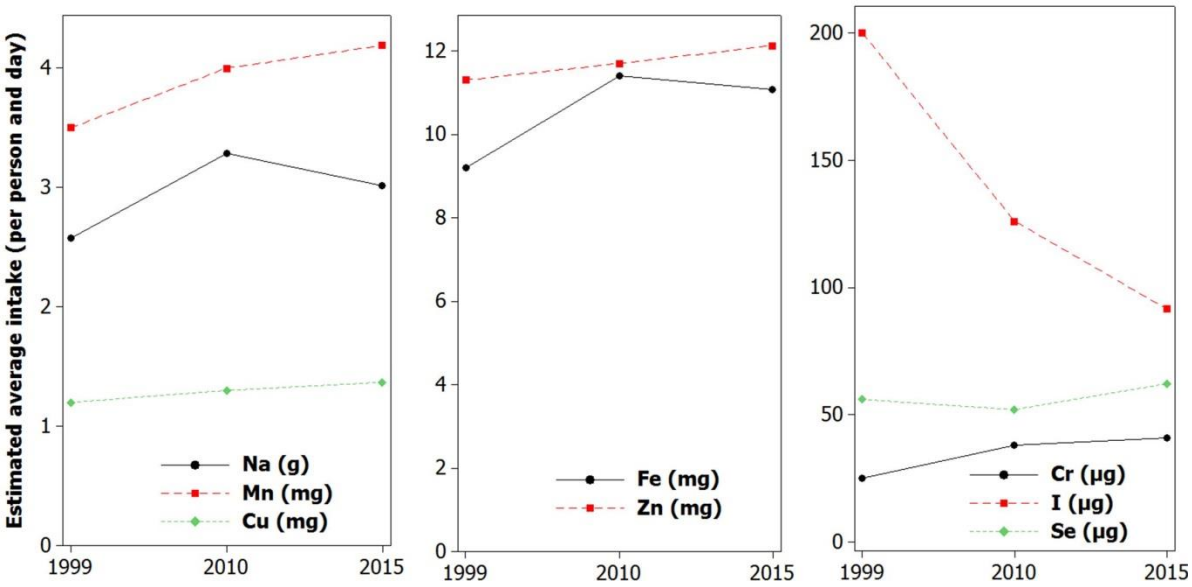


Figure 11.3:2. Estimated average intake of minerals in market baskets over time.

11.3.5 Effect of cooking

Traditionally MB analyses in Sweden were made on foods as purchased. However, as food composition might be affected by cooking, a pilot cooking study was made. Cooking might e.g. cause losses due to leakage of minerals mainly present as free ions in foods, e.g. potassium and phosphorus (Badiani et al., 2013). Furthermore, volatile minerals, such as iodine, might be lost during evaporation. It is difficult to evaluate how cooking affect retention of minerals and preferably dry weight should be used. However, for the MB the aim is not evaluate the fate of the minerals but to determine if cooking has an effect on estimated intake of the minerals. As intake of minerals is an estimation with many sources of error e.g. SBA data on production and trade, food choice and analytical measurement error, it is possible that a change in mineral concentration during cooking has no effect on the intake estimation of that mineral.

Weight changes during cooking were accounted for. Whether cooking had an effect on estimated nutrient intake was tested using Wilcoxon's signed rank test with log-transformed mineral retention as variables.

Average daily intake of essential minerals did not differ significantly when analysed as raw or as cooked (Tables 11.3:6 and 11.3:7). Cooking resulted in large discrepancy in estimated intake of selenium in cereal products and chromium in meat. For selenium it is surprising that content was higher in the cooked cereal samples. For chromium the higher concentration after cooking is most likely due to contamination during cooking, in particular since chromium was unchanged in one of the meat sample whereas it was two times higher after cooking in the other meat sample. Chromium is e.g. known to be released from cooking gear of lower quality and in a low pH environment.

Table 11.3:6. Average daily per capita intake of essential minerals (mg), analysed as purchased or as ready-to-eat.

Food group	Preparation	Cu	Fe	K	Mn	Na	P	Zn
Cereal products	Raw	0.44	3.3	530	2.3	680	360	2.7
	Cooked	0.49	3.3	510	2.3	690	400	2.7
Meat	Raw	0.15	2.6	700	0.08	760	400	4.3
	Cooked	0.14	3.1	660	0.08	740	380	4.1
Fish	Raw	0.02	0.1	120	0.02	270	73	0.2
	Cooked	0.02	0.2	120	0.02	270	74	0.2
Potatoes	Raw	0.10	0.5	550	0.16	31	61	0.3
	Cooked	0.09	0.5	470	0.15	34	59	0.3

The difference in weight between raw and cooked has been accounted for when calculating intake. Whether cooking had an effect on estimated nutrient intake was tested using Wilcoxon's signed rank test with log-transformed mineral retention as variables. Non-significant results.
.

Table 11.3:7. Average daily per capita intake of essential minerals (µg), analysed as purchased or as ready-to-eat.

Food group	Preparation	Co	Cr	I	Mo	Ni	Se
Cereal products	Raw	2.0	3.5	13	92	40	7.2
	Cooked	2.0	4.7	13	85	36	12
Meat	Raw	0.0	8.8	4.5	7.6	2.9	22
	Cooked	0.0	17	7.1	7.4	3.9	22
Fish	Raw	0.1	0.9	24	0.6	0.6	9.6
	cooked	0.1	0.8	23	0.6	0.5	8.8
Potatoes	raw	0.6	1.3	0.0	10	2.5	0.0
	cooked	0.6	1.0	0.0	8.7	2.2	0.0

The difference in weight between raw and cooked has been accounted for when calculating intake. Whether cooking had an effect on estimated nutrient intake was tested using Wilcoxon's signed rank test with log-transformed mineral retention as variables. Non-significant results.

11.3.6 Benefit and/or risk assessment

In the MB average intake of minerals has been estimated. The results should be evaluated keeping in mind that the average intake represents the average *supply* of minerals for the Swedish population, i.e. the MB results are overestimated (see chapter 13).

Estimated intakes of minerals were compared with recommendations for adults set by NNR (2012):

- *Estimated average requirement* (AR) corresponds to the mean nutrient requirement of a group, which means that 50 % are estimated to have a higher requirement and 50 % a lower requirement. Estimated intakes for all minerals, apart from iodine, were above AR. As household salt was not included iodine intake might been underestimated. For manganese, chromium, cobolt and molybdenum no AR has been set.

- *Recommended intakes* (RI) are estimated to cover the requirements of 97-98 % of the individuals in a group (AR ±2 SD). Estimated intakes for all minerals, apart from iron for women in childbearing ages and iodine, were above RI (Fig. 11.3:3). Thereby indicating that the supply of essential minerals is sufficient except for possibly iron and iodine.

An excess of essential mineral intake might have adverse health effects, hence estimated intakes were also compared with estimated upper intake levels (UL) for adults (NNR, 2012). The ULs are maximum levels of daily chronic intakes judged to be unlikely to pose a risk of adverse health effects in humans. The ULs are derived for the normal healthy population. There is however a substantial uncertainty in several of the UL values, and they must therefore be used with caution for single individuals (NNR, 2012). Thereby, the intake estimated in the MB is only appropriate to assess whether the supplies of minerals are sufficiently below the upper level. No evaluations whether certain population groups, e.g. children, may be at risk for exceeding UL may be made.

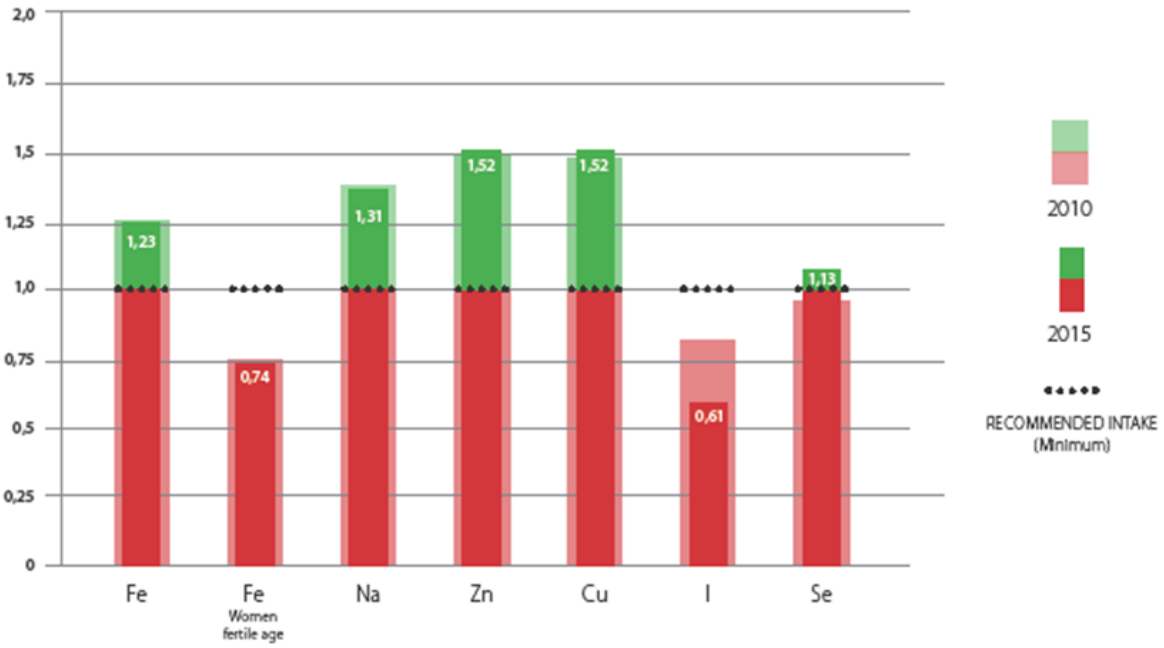


Figure 11.3:3. Supply of minerals related to recommended intake (RI) for adults 31-60 years (average between men and women, NNR, 2012). For iron, estimated intake (11 mg/day) is related to RI for adults (10 mg/day) and to RI for women of fertile age (15 mg/day). Upper intake levels are not included in the figure.

Iron. Iron is e.g. required for transport of oxygen from the lungs to tissues. The estimated intake of iron, 11 mg/day, was close to the result from the latest dietary survey on adults in Sweden (Riksmaten 2010-11, Amcoff et al 2012): 10.4 mg/day. The estimated intake of iron was in line with average requirement (AR) for women of childbearing age, i.e. 10 mg/day. In Riksmaten adults iron intake of women was lower than in men (9.5 mg/day) so most likely the gap between the average supply of iron as estimated in MB and the recommended intake (RI) for women of childbearing age (15 mg/day) is even larger than illustrated in Figure 11.3:3. Iron is poorly absorbed and apart from the iron content in the food, the amount absorbed is affected by e.g. other food components and current iron

status. Recent Swedish studies indicate that iron status needs improvement among girls and women of childbearing age (Sjöberg and Hulthen, 2015; Becker et al., 2016). In Sweden iron fortification of sifted flour ceased in 1994.
Compared to most other minerals UL for iron (25 mg/day) is set rather close to RI (8-15 mg/day), which might be troublesome. In Riksmaten adults (Amcoff et al 2012) the highest iron intake (95^{th} percentile) was reported by men aged 45-64 years (19.6 mg/day).

Potassium. Potassium is required e.g. for blood pressure regulation and for nerve and muscle function. The estimated intake of potassium, 3.9 g per day and person, was well above recommended intake 3.1 g per day for women and 3.5 g per day for men. There is no UL for potassium naturally present in foods only for potassium from supplements and fortified foods (3.7 g per day).

Sodium. There is a dose-response relation between sodium intake and blood pressure and NFA have the following dietary advice regarding salt: 'Choose food with less salt. Use less salt when you cook, but choose salt with iodine when you do use it.'

Although estimated sodium intake of 3.0 g per day was underestimated - as household salt was not included – it was higher than the population goal of 2.4 g per day (NNR, 2012). Estimated sodium supply was nearly 10% lower than MB 2010, which is positive. However, it is not possible to state whether this is a true decrease in sodium intake or not.

Phosphorus. Phosphorus is required e.g. for bone mineralisation and maintenance of acid-base homeostasis (NNR, 2012). Estimated phosphorus intake was 3 times higher than the recommended intake for adults (0.6 g/day). Phosphorus is naturally present in most foods but in higher amounts in animal products and cereals (Table 11.3:1).

In addition to phosphorus naturally present in foods, food additives containing phosphates might be a source of additional phosphorusintake. There are about 15 allowed food additives containing phosphate that can be used in a variety of foods. In USA (NHANES) there has been a significant 4% increase in phosphorus intake between 2001 and 2014, in average the intake was 1.4 g/day during this time-period (McClure et al., 2017). For Sweden, no increase in average intake has been detected in the dietary surveys for adults (HULKEN 1989: 1.43 g/day (Becker, 1994), Riksmaten 1998: 1.43 g/day (Becker and Pearson, 2002) and Riksmaten adults 2010-2011: 1.37 g/day (Amcoff et al., 2012)).

In NNR (2012) a provisional UL for phosphorus is set to 3 g/day. This provisional UL is based on the latest EFSA evaluation that concluded that 3 g/day can be a tolerated intake for normal healthy individuals. An excessive phosphorus intake is however associated with an increased risk for adverse effects on the kidneys, especially in persons already suffering from kidney disorders. In Riksmaten adults, the highest intake of phosphorus (95th percentile) was found in men aged 18-30 years having an estimated intake of 2.5 g/day (Amcoff et al., 2012). A limitation of the obtained data from Riksmaten and other studies, e.g. epidemiological studies, using food composition databases is that phosphorus content in the food items might be out-of-date, which means that a potential increase in intake as a consequence of increased use of phosphate containing additives is not taken into account. Although TDS and MB studies might overestimate the intake of all food components as food waste is not accounted for, an advantage regarding phosphorus, compared to dietary surveys using food composition databases, is that all phosphorus analyses are up-to-date and measured by the same method. Unfortunately, there is no data

on phosphorus from previous MB studies hence possible time-trends in Sweden cannot be detected using MB data.

Zinc. Zinc is required e.g. for the immune system and cell division. The estimated intake of zinc, 12 mg per day and person, was well above recommended intake 7 mg per day for women and 9 mg per day for men. There is no UL set for zinc in NNR (2012) and the risk of adverse effects due to excessive intake of zinc from food alone is considered very low (NNR, 2012). SCF (2003c) recommend an UL of 25 mg/day based on the absence of any adverse effects on a wide range of relevant indicators of copper status (as the critical endpoint).

Manganese. Manganese is e.g. involved in protein synthesis. The estimated intake of manganese, 4.2 mg per day and person, was well above estimated adequate intakes (AI) of 1.8 mg per day for women and 2.3 mg per day (Institute of Medicine, 2001; SCF, 2000a). In NNR (2012) no recommendation on intake or UL is given 'due to lack of sufficient evidence'.

Cobalt. Cobalt is required for vitamin B12, cobalamin. There are no established recommended or adequate intakes for cobalt.

Copper. Copper is required e.g. for energy metabolism and defence against free radicals. The estimated intake of copper, 1.4 mg per day and person was well above recommended intake 0.9 mg per day. UL for copper is 5.0 mg per day (NNR, 2012), based on absence of negative effects on liver function (SCF, 2003b).

Chromium. Compared to most other minerals knowledge on chromium is limited apart from chromium being considered a cofactor for insulin. The estimated intake of chromium was 41 µg per day and person. However, neither NNR (2012) nor the EU Scientific Committee for Food (SCF) has set any recommendation for chromium 'due to lack of sufficient evidence'. The Institute of Medicine (2001) estimated adequate intakes (AI) of chromium to 25 µg per day for women and 35 µg per day for men.

Neither NNR (2012) nor SCF (2003a) has set any UL for chromium. The EFSA Panel on Contaminants in the Food Chain, however, have set a TDI of 300 µg/kg body weight per day for chromium in trivalent form (Cr(III)) based on the lowest NOAEL identified in a chronic oral toxicity study in rats (EFSA CONTAM Panel, 2014).

Iodine. Iodine is e.g. required for synthesis of the thyroid hormones. Estimated intake of 92 µg per day was low compared to recommended intake of 150 µg per day. However, a comparison is misleading since (iodized fortified) household salt and water (for cooking and drinking purposes) is not included in the market basket. Still, compared to previous market baskets there is a troublesome trend (Figure 11.3:2) with a reduction of estimated intake by 50% the last 15 years. Iodine intake was not estimated in Riksmaten adults.

UL is set to 600 µg per day (NNR, 2012). Insufficient iodine status has recently been reported for Swedish women in Riksmaten adults (Becker et al., 2016). The authors conclude 'a general increase in iodine intake is desirable, especially important for women of childbearing age'.

Molybdenum. Compared to most other minerals knowledge on molybdenum is limited. Molybdenum is e.g. part of enzymes involved in amino acid catabolism. The estimated intake of molybdenum, 172 µg per day and person, was high compared to Recommended Dietary Allowance in USA (Institute of Medicine 2001): 45 µg per day. In NNR (2012) no recommendation on intake or UL is given 'due to lack of sufficient evidence'. The Scientific Committee on Food (SCF) set the UL at 600 µg per day for adults (SCF, 2000b).

Selenium. Selenium is required e.g. for antioxidant activity and thyroid hormone metabolism. The estimated intake of selenium, 62 µg per day and person, was close to estimated intake in Riksmaten adults (57 µg, Amcoff et al., 2012) and has increased compared with previous MB studies. Estimated intake of selenium was close to the recommended intake of 50 µg per day for women and 60 µg per day for men. UL is set to 300 µg per day by NNR (2012) and SCF (2000c).

11.3.7 Conclusion

Average estimated supplies of all essential minerals were close to or above average requirements. It is, however, important to remember that the mineral supply – as assessed using the MB - is not equal to the mineral intake, which is lower than the supply (see chapter 13). Despite this overestimation, supplies of iodine and iron in women of fertile ages were below recommended daily intakes (NNR, 2012). It should be noted that iodine results are underestimated as no household salt (non-iodised and iodised) was included in the study. Still, for iodine there has been a decreasing trend over the last 15 years. This might in part be a consequence of changes in feed composition, e.g. proportion of marine feed in aquaculture. Furthermore, it might be due to limited use of iodised salt in the food industry, e.g. no iodine was found in cured and processed meats.

Sodium supply was above the population goal despite that household salt was not included in the study. 'Cereals', 'cured and processed meats' and 'sugar and sweets' contributed with about 50 % of the sodium supply. The results indicate that salt content in cured and processed meats have decreased since 2015.

Average estimated daily intakes of essential minerals do not vary significantly on food category basis when food samples were analysed as purchased or as consumed.

There are some important limitations with the MB study that are important to remember when evaluating the results e.g.: 1) errors associated with uncertainty in per capita consumption; 2) errors associated with food choice and proportions within each food group; 3) measurement errors for determination of contents; 4) difference between supply and estimated intakes. Despite those limitations, the results indicate that intakes of sodium/salt, iodine and for women of childbearing age also iron, are not in line with NNR.

11.4 Non-essential mineral elements

11.4.1 Background

There are several mineral elements in food that are not essential for humans, but are present in the food mainly due to their natural presence in nature. The most commonly mentioned elements are the so called "heavy metals" including lead, cadmium, mercury and arsenic, which all have proven toxic effects and also are among the WHO top-ten chemicals of major health concern (IPCS, 2017). However, in addition to the "heavy metals" there are also an interest in; silver (EFSA, 2016), aluminum (EFSA, 2008) and nickel (EFSA, 2015). All three elements are present naturally in food, but there is an increasing use of silver as a food preservative agent, and aluminum could be used as both a food additive and in the production of drinking water making the element of interest. Nickel has recently become of more interest and needs further evaluation according to EFSA. According to EFSA 2015 nickel in food can induce eczematous skin reactions among nickel-sensitized individuals. In addition, it has been shown that nickel cause effects on reproduction and development in experimental animals. All non-essential mineral elements have been analyzed to give their total content in the different food categories, but for arsenic additional analyses have been performed to give the content of inorganic arsenic, which is seen as the most toxic form of arsenic that is present in food.

11.4.2 Chemical analysis

The analysis of total concentrations of non-essential (and essential) elements in the samples were performed by ALS Scandinavia AB, Luleå by High Resolution Inductively Coupled Plasma Mass Spectrometry (HR-ICP-MS). In order to achieve lowest possible detection limits and to avoid contamination risks associated with additional homogenization of samples, sample amount was increased to >1 g per digestion. Weighing was done directly into acid washed, 50 ml plastic vessels. After addition of concentrated nitric acid (10:1, v/m), samples were left to react overnight followed by graphite hot-block digestion (105˚C, 2 hours). After cooling, volume of transparent digests was adjusted to 40 ml with MQ-water. Prior to analysis stage, samples were further diluted to provide total dilution factor of approximately 100 and nitric acid concentration of 1.4 M. A set of preparation blanks, duplicate samples and control materials was prepared alongside with samples.

Concentration of elements of interest were measured by HR-ICP-MS (ELEMENT XR, Thermo Scientific), using combination of internal standardization (In and Lu added to all solutions at 1 µg/l) and external calibration with set of standards matching sample digests in acid strength. All-PFA introduction system, high sensitivity X-type skimmer cone and FAST autosampler (excluding contact of sample digests with peristaltic pump tubing) allows instrumental sensitivity in excess of 2000 counts/s for 1 ng/l Indium-115 and background equivalent concentrations for ultra-trace elements (cadmium, lead, arsenic) below 0.2 ng/l. In order to minimize matrix effects and to increase sensitivity of arsenic, selenium and cadmium, the ICP was operated with methane addition. Spectral interferences were either avoided using high resolution settings of MS or mathematically corrected (tin, indium and molybdenum oxide interferences on cadmium isotopes). Method detection limits (defined as 3 times the standard deviation of analyte concentrations measured in a set of preparation blanks) is presented in Table 11.4:1 and the measurement uncertainty is between 30 and 50 % depending on the element and its

level of concentration. The method is based on the accredited method that ALS Scandinavia AB use in their routine work for analysis of biological matrices (Engström et al., 2004; Rodushkin et al., 2008). 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 11.4:1. Limits of detection (LOD, 3*std for blank, n=9) for non-essential elements measured by high resolution-ICP-MS by ALS Scandinavia AB, Luleå.

Type of sample	Limit of detection, µg/kg						
	As	Ag	Al	Cd	Hg	Ni	Pb
Solid	1.4	0.8	46	0.2	1.6	7	1.1
Liquid	0.7	0.4	23	0.1	0.8	4	0.6

The analysis of inorganic arsenic was performed by HPLC-ICP-MS (high performance liquid chromatography – inductively coupled plasma mass spectrometry) in the Swedish NFA laboratory. An HPLC (Agilent 1260) equipped with a strong anion exchange column (Dionex Ionpac AS7 and precolumn Dionex Ionpac AG7) were used to separate the different arsenic compounds in the sample. The analytical method is accredited in accordance with ISO/IEC 17025 by SWEDAC for inorganic arsenic in food within the range 1-25 000 µg/kg and is since March 2016 a European standard (EN 16082). The limit of detection (LOD) was between 1 and 3 µg iAs/kg depending on the dilution of the sample before analysis, and the measurement uncertainty was +/- 26 %.

11.4.3 Analytical results

The total concentration of the non-essential elements were determined in each of the five samples of the twelve food categories. Regarding inorganic arsenic only food groups that earlier had shown results above LOD (1 and 2 µg/kg for wet and dry samples respectively) were analyzed, i.e. cereal products, fish, fruits and sugar and sweets (Kollander et al., 2015). The results are presented in Table 11.4:2 (complete data set presented in Annex VII). Generally, cereal products contain the highest amounts of inorganic arsenic, aluminium, and cadmium, as well as high amounts of silver, nickel and lead. The amounts in cereal products are closely followed by sugar and sweets which contain among the highest levels of inorganic arsenic, aluminium, nickel and lead. In vegetables and dairy products (solid) the highest amounts of lead were found, around 10 µg/kg, but the variation is large in both food categories with minimum levels below 2 µg/kg.

Arsenic, inorganic (iAs) and total (tAs). Fish contain the outstanding highest levels of arsenic (mainly organic forms of), when comparing all food categories. The mean and median are around 1200 µg tAs/kg, while the inorganic arsenic is much lower with a mean and median of around 2 µg/kg. The content of iAs in fish is thus less than 0.2 percent. The food group with the highest content of iAs is cereal products with a mean and median of around 9 µg iAs/kg. In this group also the tAs levels are in the same area, around 11 tAs/kg, thus revealing that iAs is the major species of As in cereal products.

Silver (Ag). Silver was detected in five of the twelve food categories; cereals, pastries, pizza and pirogues, fish and potatoes. The mean levels in fish are around 3 µg/kg and contain, together with pastries, the highest silver levels found in this study.

Aluminium (Al). Sugar and sweets contain high amounts of Al, ranging from 2600 to 6900 µg/kg. Also food categories containing cereals like cereals products, pastries and pizza, mainly have Al levels at thousands of µg Al/kg, while dairy products (liquid), Eggs and Beverages have levels less than 100 µg Al/kg. In the middle range there are meat, fish, fruit, and vegetables with a few hundreds of µg Al/kg.

Cadmium (Cd). The highest levels of Cd are found in cereal products and potatoes which have means and medians around 25 µg/kg, followed by pastries and pizza with 15 µg/kg. Sugar and sweets together with vegetables, have slightly lower mean and medians of 12 and 10 µg/kg respectively. Cd levels around and below the detection limits were found in dairy products and eggs.

Mercury (Hg). Generally, most food categories contain Hg at a level below the detection limit. Fish is the category that contain the highest levels with a mean around 30 µg/kg per fresh fish. There were also detectable amounts of Hg in two of the egg groups, 1.8 and 2.8 µg/kg respectively.

Nickel (Ni). Sugar and sweets contain the highest amounts of Ni, ranging from 300 to 400 µg/kg. Cereal products and pastries are close with levels ranging from 100 to 300 µg/kg, while pizza and pirogues, vegetables, fruit, and potatoes are ranging between 10 to 100 µg/kg. Lowest amounts, around and below the detection limit, are found in dairy products, beverages, fats and oils, and eggs.

Lead (Pb). Lead is measurable in all food categories but the food category with the lowest concentrations is found in eggs. Here both mean and median are below the detection limit of 1.1 µg/kg and only one value, 2.0 µg/kg are above. The highest amounts are found in vegetables, dairy (solid) and in sugar and sweets with maximum levels of around 10 µg/kg or higher. The range in obtained results of Pb from the samples in these categories are larger than in other food categories like cereals, fish and fruits. The wide range is also reflected in the mean and median values 4.2 and 2.4 µg/kg for dairy products (solid), and 4.4 and 2.9 µg/kg for vegetables, respectively. This could be compared with Cereal products where the different samples are more uniform regarding Pb levels. Here both the mean and the median for lead is 4.8 µg/kg.

Table 11.4:2. Total concentrations of non-essential elements in µg/kg, including arsenic (tAs), silver (Ag), aluminium (Al), cadmium (Cd), mercury (Hg), nickel (Ni), lead (Pb) and also inorganic arsenic (iAs). Note that values below the detection limit are counted as half the detection limit. Therefore the mean and the median can be presented with values below the detection limit. (n.a. = not analysed).

Food Group		**Concentration in µg/kg**							
		iAs	**tAs**	**Ag**	**Al**	**Cd**	**Hg**	**Ni**	**Pb**
Cereal products	Mean	8.8	10.5	2.4	3058	25.5	< 1.6	192	4.8
N=5	Median	8.8	10.9	2.5	1232	24.5	< 1.6	219	4.8

Food Group		Concentration in µg/kg							
		iAs	**tAs**	**Ag**	**Al**	**Cd**	**Hg**	**Ni**	**Pb**
	Min	6.2	8.1	1.9	870	21.8	< 1.6	121	3.2
	Max	11.4	12.0	3.0	10753	32.8	< 1.6	268	6.7
Pastries	Mean	n.a.	3.1	3.0	1571	15.5	< 1.6	137	4.5
N=5	Median		3.0	3.3	1534	16.3	< 1.6	134	3.9
	Min		1.8	1.4	1094	11.6	< 1.6	108	3.0
	Max		5.2	5.2	2368	16.8	< 1.6	161	6.1
Pizza, pirogue	Mean	n.a.	4.7	1.4	1743	14.2	< 1.6	55	3.7
N=5	Median		4.5	1.4	1339	14.4	< 1.6	46	4.1
	Min		2.7	1.1	859	11.0	< 1.6	44	2.8
	Max		7.8	1.7	3259	16.1	< 1.6	94	4.4
Meat	Mean	n.a	2.2	< 0.8	449	2.5	< 1.6	13	2.4
N=5	Median		2.5	< 0.8	374	2.4	< 1.6	13	1.9
	Min		1.9	< 0.8	308	2.0	< 1.6	9	1.5
	Max		3.1	0.9	758	3.4	< 1.6	16	4.8
Processed meats	Mean	n.a.	1.5	< 0.8	868	1.5	< 1.6	< 7	2.3
N=5	Median		1.5	< 0.8	729	1.4	< 1.6	< 7	2.6
	Min		1.3	< 0.8	440	1.2	< 1.6	< 7	1.5
	Max		1.7	0.8	1418	2.0	< 1.6	10.0	2.8
Fish	Mean	2.1	1283	3.1	286	4.7	29.4	9	1.5
N=5	Median	2.2	1193	3.0	231	5.2	29.9	7	1.3
	Min	< 1.7	859	1.5	193	3.4	23.2	< 7	1.2
	Max	2.8	2013	5.5	528	5.3	40.5	21	2.0
Dairy products, solids	Mean	n.a.	5.4	< 0.8	525	0.2	< 1.6	< 7	4.2
N=5	Median		2.3	< 0.8	423	< 0.2	< 1.6	< 7	2.4
	Min		1.5	< 0.8	234	< 0.2	< 1.6	< 7	1.5
	Max		16.8	< 0.8	1104	0.5	< 1.6	< 7	10.6
Dairy products, liquids	Mean	n.a.	0.6	< 0.4	39	0.2	< 0.8	< 4	1.8
N=5	Median		0.3	< 0.4	39	0.2	< 0.8	< 4	1.0
	Min		< 0.7	< 0.4	31	0.2	< 0.8	< 4	0.6
	Max		1.0	< 0.4	45	0.2	< 0.8	10	5.3
Eggs	Mean	n.a.	2.8	< 0.8	47	< 0.2	< 1.6	< 7	< 1.1
N=5	Median		2.6	< 0.8	53	< 0.2	< 1.6	< 7	< 1.1
	Min		1.6	< 0.8	53	< 0.2	1.8	< 7	< 1.1
	Max		5.4	< 0.8	82	0.2	2.8	< 7	2.0
Fats and oils	Mean	n.a.	2.4	< 0.8	584	0.2	< 1.6	< 7	1.3

Food Group		Concentration in µg/kg							
		iAs	**tAs**	**Ag**	**Al**	**Cd**	**Hg**	**Ni**	**Pb**
N=5	Median		1.8	< 0.8	541	0.3	< 1.6	< 7	0.6
	Min		1.5	< 0.8	409	< 0.2	< 1.6	< 7	< 1.1
	Max		4.1	< 0.8	957	0.3	< 1.6	< 7	3.6
Vegetables	Mean	n.a.	< 1.4	< 0.8	266	10.3	< 1.6	39	4.4
N=5	Median		< 1.4	< 0.8	239	9.5	< 1.6	37	2.9
	Min		< 1.4	< 0.8	156	7.9	< 1.6	31	1.8
	Max		3.9	< 0.8	373	15.6	< 1.6	48	9.6
Fruits	Mean	1.2	2.7	< 0.8	474	1.5	< 1.6	80	3.2
N=5	Median	1.5	2.8	< 0.8	443	1.3	< 1.6	75	3.2
	Min	< 1.3	1.9	< 0.8	319	1.1	< 1.6	35	2.8
	Max	1.6	3.1	< 0.8	633	2.3	< 1.6	146	3.8
Potatoes	Mean	n.a.	< 1.4	1.0	181	25.0	< 1.6	46	1.2
N=5	Median		< 1.4	0.9	220	25.4	< 1.6	36	1.2
	Min		< 1.4	< 0.8	97	15.9	< 1.6	19	< 1.1
	Max		2.1	1.5	262	30.5	< 1.6	118	2.5
Sugar and sweets	Mean	7.3	7.5	< 0.8	4270	11.8	< 1.6	366	10.7
N=5	Median	4.0	7.2	< 0.8	3321	11.8	< 1.6	366	9.6
	Min	1.6	4.0	< 0.8	2613	9.8	< 1.6	337	5.4
	Max	16.1	12.4	< 0.8	6917	15.0	< 1.6	393	16.4
Beverages	Mean	n.a.	0.6	< 0.4	58	< 0.1	< 0.8	< 4	2.3
N=5	Median		0.7	< 0.4	64	< 0.1	< 0.8	< 4	1.9
	Min		< 0.7	< 0.4	45	< 0.1	< 0.8	< 4	< 0.6
	Max		0.8	< 0.4	69	< 0.1	< 0.8	< 4	5.0

11.4.4 Exposure estimation, time trends

The average daily per capita, and per kg body weight exposure, of the non-essential elements analyzed is shown in Table 11.4:3. The relative intakes of these metals from the different food categories (in percent of total) are given in Table 11.4:4.

Table 11.4:3. Intake of non-essential elements from the different food groups in µg/person/day, and in µg/kg bw/day (using a per capita body weight of 76.6 kg). For detailed information on the respective levels in each food category (mean of five market basket samples) se Table 11.4:2 and Annex VII.

Food category	Mean consum., g/d	iAs	tAs	Ag	Al	Cd	Hg	Ni	Pb
Cereal prod.	229	2.0	2.4	0.55	282[1]	5.8	0.18	44	1.1
Pastries	48	na	0.15	0.14	75	0.74	0.04	6.6	0.22
Meat	212	na	0.47	0.08	95	0.53	0.17	2.5	0.51
Fish	46	0.10	59	0.14	13	0.22	1.4	0.41	0.07
Dairy pr., fluid	323	na	0.43	0.03	41	0.02	0.06	0.28	0.19[1]
Dairy pr., solid	79	na	0.19	0.06	13	0.06	0.13	0.65	0.32[1]
Eggs	28	na	0.08	0.01	1.3	0.00	0.02	0.10	0.04
Fats and oils	45	na	0.11	0.02	26	0.01	0.04	0.16	0.06
Vegetables	198	na	0.08	0.08	53	2.0	0.16	7.7	0.87
Fruits	233	0.30	0.63	0.09	110	0.35	0.19	18	0.75
Potatoes	126	na	0.09	0.13	23	3.1	0.10	5.8	0.14
Sugar, sweets	126	0.15	0.95	0.05	538	1.5	0.04	46	1.4
Beverages	315	na	0.19	0.06	18	0.02	0.13	0.63	0.72
Total (µg/day)		2.5	65	1.5	1290	14	2.6	133	6.3
Total (µg/kg bw/day)		0.033	0.84	0.019	16	0.19	0.034	1.7	0.083

[1] Based on median levels, because of skewness in level distribution (see Table 11.4:2 and Annex VII)
na = not analysed.

Table 11.4:4. Relative contribution (in % of total intake) from different food categories to the total intake of the studied non-essential elements

Food group	tAs	Ag	Al	Cd	Hg	Ni	Pb
Cereal products	3.7	38	22	40	7.0	33	17
Pastries	0.2	9.9	5.8	5.1	1.5	4.9	3.4
Meat	0.7	5.8	7.4	3.7	6.5	1.9	8.0
Fish	91	9.8	1.0	1.5	52	0.3	1.1
Dairy prod., fluid	0.3	4.4	1.0	0.4	5.0	0.5	5.1
Dairy prod., solid	0.7	2.2	3.2	0.1	2.4	0.2	3.0
Eggs	0.1	0.8	0.1	0.0	0.9	0.1	0.6
Fats and oils	0.2	1.2	2.0	0.1	1.4	0.1	0.9
Vegetables	0.1	5.4	4.1	14	6.1	5.8	14
Fruits	1.0	6.4	8.6	2.4	7.2	14	12
Potatoes	0.1	8.6	1.8	22	3.9	4.3	2.2
Sugar and sweets	1.5	3.5	42	10	1.5	34	21
Beverages	0.3	4.3	1.4	0.1	4.8	0.5	11

Below, comparisons are made between the different market basket sampling occasions, 1999, 2010, and 2015 (the 2005 Market Basket study did not include analysis of non-essential elements in the market basket sample food mixtures). Since detection limits have changed for some of the elements or matrices during this time period, analyses of time trends must be done with caution. Changes in consumption patterns, resulting in a changed composition of the purchased market baskets, may be one cause of increased or decreased intake of certain elements.

Arsenic (As)

The analysis of arsenic has been divided into the total amount of arsenic, tAs, and inorganic arsenic, iAs. The daily mean intake per capita of tAs and iAs is estimated to 65 µg and 2.5 µg per person and day, respectively. The corresponding intake per kg b.w. is 0.84 and 0.033, see Table 11.4:3. It is worth noting that the analysis of iAs in MB 2015 was only made of the four food groups that contained measurable amounts of iAs in the earlier analysed 2010 MB. The other eight food categories are regarded as not contributing to the intake of iAs in any significant extent. In the Market Basket study of 2010 originally only the amount of tAs was analyzed and evaluated in the different food groups. The intake per capita of tAs in 2010 was calculated to about 145 µg/kg, which is twice as much as today's 65 µg/kg. However, the results in the present study should be more close to true values, since the analytical method now used have a higher sensitivity and lower levels can be quantified. In 2010, most of the results for tAs were estimated from half the LOQ giving "concentrations" of 15 µg tAs/kg food sample which is roughly ten times higher than the quantified results of tAs in the present study.

The contribution of arsenic varies between food groups. Concerning tAs, the contribution from fish is the highest, but the contribution of iAs is highest from cereals. However, the inorganic forms of arsenic are more toxic as compared to organic arsenic, and the presentation of iAs data in this project is therefore important from a risk assessment point of view.

Silver (Ag)

For silver the daily per capita exposure is estimated to 1.5 µg (Table 11.4:3). This corresponds to a daily exposure of 0.02 µg/kg b.w. if considering a standard body weight of 76.6 kg. The contribution to exposure is highest from cereals. In comparison with the data obtained from the market basket of 2010 (7.2 µg/person/day), todays value is much lower. This may be an effect of a lower LOQ in the present study and that the 2010 data is based on UB values (values below LOQ were approximated to be equal to LOQ.

Aluminium (Al)
For aluminium the daily per capita intake is estimated to 1.3 mg per person (Table 11.4:3), which is about the same as the earlier Market Basket study from 2010. The present results correspond to a weekly exposure of 0.12 mg/kg b.w. if considering a standard body weight of 76.6 kg and the use of median level in cereals (see footnote Table 11.4:3).

Cadmium (Cd)
For cadmium the daily per capita exposure is estimated to 14 µg (Table 11.4:3). This corresponds to a weekly exposure of 1.3 µg/kg b.w. if considering a standard body weight of 76.6 kg. This result is quite similar to that obtained in a more detailed assessment of the cadmium exposure in the adult Swedish population where the median intake was estimated to 1 µg/kg. b.w./week (Sand and Becker, 2012). The present results are also roughly similar to those obtained in previous assessments based on market basket analyses in 1987 (12 µg/person/day) (Becker and Kumpulainen, 1991) and in 1999 (10 µg/person/day) (Becker et al., 2011). However, from 1999 and on, the per capita intakes seem to show an increasing trend, with a 50% increase in Market Baskets from 1999 to 2015 (Fig. 11.4:1). In comparison with an estimation made by EFSA, the mean Cd intake in EU is about 2.3 µg/kg, b.w., per week, (EFSA, 2009a). As can be seen in Table 11.4:4, cereals, vegetables and potatoes are the main contributors to the cadmium exposure on average. Because of a high consumption of cereal products, vegetarians may have relatively higher Cd intakes (EFSA, 2009a).

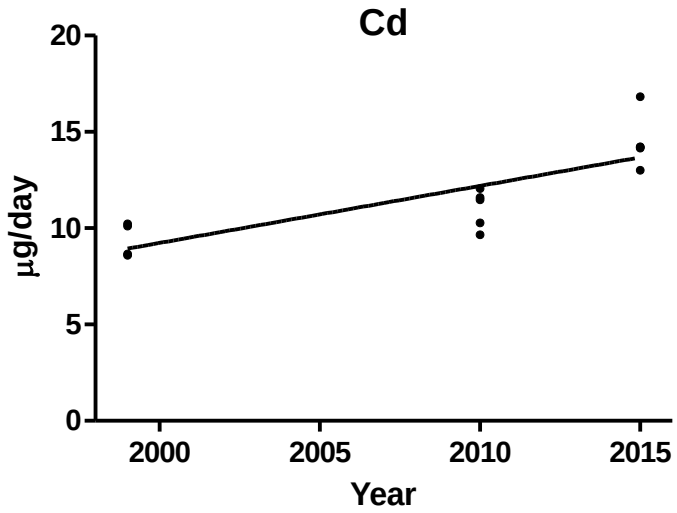


Fig. 11.4:1. Graph of per capita intake of cadmium (in µg/person/day) based on calculations from tree Swedish market basket studies, indicating an increasing time trend. A linear regression line is inserted and an increasing trend is statistically significant (simple regression analysis, P<0.001, N-numbers: 1999=4; 2010=5; 2015=5). No metal analyses of market basket homogenates were performed in 2005.

An explanation to the suggested increase in Cd intake could be increased consumption of cereals and vegetables, over the actual period 1999-2015 (see Table 10:1), and due to that cereals, vegetables and potatoes constitute the three major food intake sources for Cd. In addition, for all these three food categories Cd levels in food samples are higher in 2015 compared to 2010 (analytical considerations could not explain the difference). Also, whole grain products, in general, contain more cadmium than the corresponding non-whole grain products.

Mercury (Hg)
For mercury, the daily per capita exposure is estimated to 2.6 µg (Table 11.4:3). This corresponds to a weekly exposure of 0.24 µg/kg b.w. if considering a standard body weight of 76.6 kg. This result is in line with earlier studies made in Sweden, (Becker and Kumpulainen, 1991, Ankarberg and Peterson Grawé, 2005).

Fish is the main contributor to the Hg exposure, while other food groups contribute little to the total exposure (Table 11.4:3). Compared to the present study (1.35 µg per person and day from fish), a somewhat higher per capita intake from fish is seen in MB 2010 (1.61 µg per person and day) but a lower intake was seen in the 1999 study (1.17 µg per person and day; however based on only two values). Statistical evaluation of Hg data from 1999, 2010 and 2015 revealed no significant time trend. According to the SBA consumption statistics, fish consumption has increased over the time 1999-2015, which may have influence on the Hg intake over this time period.

Nickel (Ni)

For nickel the daily per capita exposure is estimated to 133 µg (Table 11.4:3). This corresponds to a daily exposure of 1.7 µg/kg b.w., if considering a standard body weight of 76.6 kg. Data from The Market basket study of 2010 indicated a similar intake. Sugar and sweets, and cereal products contribute most to nickel exposure, on average (Table 11.4:4).

Lead (Pb)

For lead the daily per capita exposure is estimated to 6.3 µg (Table 11.4:3). This exposure is roughly similar to that observered in the latest MB study from 2010 and also to that shown in the market basket analyses in 1999, if values below LOQ are treated similarly. Statistical evaluation of values from these three MB studies suggested no time trend. In comparison to even older data (17 µg/person and day), based on a study from 1987 using a similar MB method (Becker et al., 2011), the present per capita exposure is much lower. The estimated exposure in this study corresponds to a daily exposure to 0.083 µg/kg b.w. if considering a standard body weight of 76.6 kg.

Among many contributing food categories to the exposure of lead via food we find sugar and sweets, and cereal products (Table 11.4:4). It is generally agreed that the exposure of Pb has decreased significantly during the last decades, which is mainly due to the removal of lead from petrol. This is mirrored by a decreased intake by comparing market basket data between 1987 and 1999 but no further decrease is seen between 1999 and 2015.

11.4.5 Effect of cooking

Food items in some of the food categories like rice, pasta, potatoes, meat and fish were cooked as for consumption, before they were added to their respective homogenates which subsequently represented "cooked" food categories. The food items were weighed before and after the cooking procedure. The aim was to estimate a more realistic intake from the food categories including food items that normally are consumed as cooked. Note that the relative number of food items within a category that was subjected to cooking varied between the four food categories (cereals, meat, fish, potatoes) and this may influence the comparison uncooked-cooked (see also Chapter 7). Table 11.4:5 shows the calculated intake of the non-essential elements before and after cooking.

Table 11.4:5. Comparison of cooked and non-cooked food on estimations of per capita intake of selected food categories (intake in µg/person/day; each value is the mean of two samples, corrections for cooking-induced weight changes are made).

Food categories	iAs	tAs	Ag	Al	Cd	Hg	Ni	Pb
Cereal prod.								
uncooked	2.3	2.5	0.63	278	5.6	nc	51	1.1
cooked	2.0	2.4	0.75	265	5.7	nc	36	1.0
Meat								
uncooked	na	0.53	nc	120	0.57	nc	3.0	0.75
cooked	na	0.45	nc	98	0.41	nc	3.9	0.55
Fish								
uncooked	0.12	54	0.16	18	0.22	1.21	0.64	0.09
cooked	0.08 (1	49	0.17	21	0.21	1.58	0.52	0.15
Potatoes								
uncooked	na	nc	0.12	30	2.6	nc	2.6	0.32
cooked	na	nc	0.10	23	2.5	nc	1.8	0.36

na = not analyzed
nc = not compared; too many values beneath LOQ (>2 out of 4)
1) one value <LOQ

The result from the cooking study show in general rather small changes, which perhaps also was to expect since the total concentration of these elements will not change due to heating, in contrast to what could be the case for e.g. certain vitamins. It should also be noted that only some food items within the mentioned food categories were cooked (which should mirror the common cooking procedures), and therefore the changes in intake between cooked and uncooked food categories, if any, should be limited.

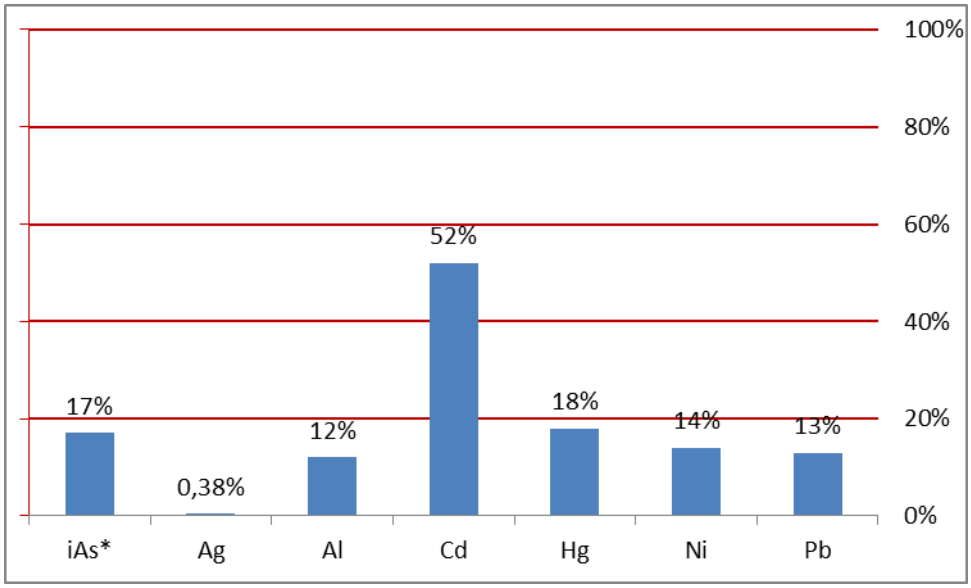
The results from Table 11.4:5 generally show small or no differences in estimated intakes between cooked and uncooked food categories. In case where modest differences are seen (Pb decreases in fish, Cd decreases in meat, and Ni decreases in cereals and increases in meat) the levels are low which increases the analytical measurement uncertainty. In case of the increased Hg intake in fish after cooking, the weight change in the cooked fish may not have been fully compensated for. In general, what could happen during cooking is that juice from the food item (meat or fish) could leave the food containing various concentrations of the compound of interest (we do not include the meat/fish juice in the post-cooking weighing), or that boiling in water could soak out these compounds. The latter case has been show earlier when boiling rice with a large volume of water, and

discarding the excess, could decrease the levels of certain metals considerably, in comparison to boiling with an exact amount of water (Abramsson-Zetterberg et al., 2016). Another potential issue is that some of the non-essential elements are present in indoor environment, such as Al and Ni in the kitchen equipment, Pb at low levels in natural dust and several metals found in tap water used for cooking (see Table 7.1). This could result in contamination of the food sample during the cooking procedure. However, we could not see any general increase in levels and intake of these metals following the cooking procedure.

To conclude, the calculated intake changes are at most rather modest and pointing in both directions, lacking an obvious pattern. If the analytical measurement uncertainty is included in the evaluation, these is not much evidence that cooking of food items of the selected food categories should have any considerable influence of the estimated intakes of non-essential metals from food included in the MB study.

11.4.6 Risk assessment

The studied non-essential elements have adverse effects in higher doses, and TDI/TWIs, or other types of health-based reference doses, are established based on these toxic effects. Fig. 11.4:2 gives a compilation of per capita intakes of the non-essential elements studied in the present market basket study, in relation to the various health-based reference doses. More specific data on the risk assessment of the various metals is given below.



*iAs intake based on data from MB 2010 and MB 2015 (see text)

Fig. 11.4:2. Per capita intakes of studied metals in relation to respective health-based reference values (=100%; see text for further details)

Arsenic

The estimated range of mean intake of iAs across Europe is 0.13 to 0.56 µg/kg b.w. per day, although based on (high) default values in fish (EFSA, 2009b). The present MB data

suggest a comparably low Swedish intake (i.e. 0.03 µg/kg b.w. per day). To improve the assessment, recent iAs analyses of the MB 2010 samples (Kollander et al., 2015) were considered showing that the four food categories analysed in the present study (MB 2015) constituted about 70% of the total iAs intake from all twelve groups, if non-detects were approximated with ½LOQ-values (unpublished observations). Thus, a more correct iAs intake from our study would likely be 0.05 µg/kg b.w. per day.

EFSA have established reference points for iAs. which correspond to a response of 1% ($BMDL_{01}$); they identified a range of 0.3-8 µg/kg b.w./day for cancers of the lung. skin and bladder. as well as skin lesions (EFSA, 2009b). According to MB 2015, the estimated dietary exposures to inorganic arsenic for average level consumers in Sweden are well below this range. Even so, the possibility of a risk to some consumers cannot be excluded (EFSA, 2009b).

Silver
Pigmentation of the eye is considered to be the first sign of generalized *argyria*, WHO (2003) considers that a total lifetime oral exposure of about 10 g of silver canbe considered as the human no-observed-adverse effect level (NOAEL). This translates to a daily exposure to 0.4 mg/day (during 70 years). The present calculated intake of silver, 1.5 µg/person/ day, is very low in relation to the lifetime NOAEL suggested by WHO. It is important to mention that the safety of silver as a food additive might be different since such silver sometimes have a different particle size distribution (EFSA, 2016a).

Aluminium
The major route of exposure to Al for the general population is through food. EFSA has summarized the calculated daily intake of Al in some of the countries in EU and it shows a wide range between 1.6 to 13 mg/person and day (EFSA, 2008a). Based on an adverse effect on the nervous system, EFSA proposed a no-observed adverse-effect level (NOAEL) to be between 10 and 42 mg Al/kg bw per day. This was based on several studies in mice, rats and dogs. Taken into account several aspects EFSA established a TWI of 1 mg/kg b.w. (EFSA, 2008a). This could be compared to the calculated mean intake of Al in this study, 0.11 mg/kg. b.w. and week. In the present data, sugar and sweets, cereal products and dairy products are the main contributors to the intake (Table 11.4:2). This suggests that the mean Al intake, but not necessarily extreme intakes, are well below the TWI.

The bioavailability of Al from food and beverages is generally considered to be low, about 0.1%. However, it is likely that the oral absorption of Al from food can vary at least 10-fold depending on the chemical forms present (EFSA, 2008a). The exposure from non-dietary sources may be considerable for some persons, depending on e.g. life-style and medication.

Cadmium
Foodstuffs are the main source of cadmium exposure for the non-smoking general population. Cd absorption after dietary exposure in humans is relatively low (3–5 %) but Cd is efficiently retained in the kidney and liver in the human body, with a very long biological half-life ranging from 10 to 30 years (EFSA, 2009a). Cadmium is toxic to the kidney, where it accumulates over time and may cause renal dysfunction. In addition, osteoporosis and cardiovascular effects have been attributed to Cd exposure (Engström et al., 2011; Satarug et al., 2017). Cd exposure is associated with increased cancer risk,

specifically in the lung, endometrium, bladder and breast. IARC has classified cadmium as a human carcinogen (Group 1) on the basis of occupational studies.

Cd has been risk assessed several times, e.g. by WHO. Due to a high mean intake in EU and thereby a small marginal to undesirable health effects, EFSA was asked to re-evaluate the risks to human health. Based on the Cd level in human urine where the variability in absorption and variation in half-life were taken into account. EFSA established a tolerable weekly intake of 2.5 µg/kg b.w. According to the present per capita weekly intake of 1.3 µg/kg b.w. there appears to be a limited margin for a Swedish mean consumer to the tolerable weekly intake of 2.5 µg/kg b.w. established by EFSA (EFSA, 2009a) (see Figure 11.4:2).

Mercury
Hg occurs in different chemical forms where the inorganic form is the most toxic and the organic form, methyl-Hg is less toxic, but far more common in the food chain. In a follow up study from the Seychelles, Efsa pointed to an association between prenatal methylmercury exposure and decreased scores on neurodevelopmental endpoints (EFSA, 2012a). According to these results EFSA proposed an uncertainty factor of 6 and established a TWI (tolerable weekly intake) of 1.3 µg/kg. b.w.,expressed as mercury. This could be compared to the estimated per capita intake of 0.24 µg/kg. b.w in the present study (Fig. 11.4:2).

Nickel
EFSA concluded that Ni-sensitized individuals are at risk of developing eczematous flare-up skin reactions through the consumption of food of animal origin. The contribution from food of animal origin to the human dietary Ni exposure should therefore not be underestimated, particularly in age classes with high dietary exposure to Ni (EFSA, 2015).However, the mean Ni per capita intake from food is low (1.7 µg/kg b.w.) in relation to the tolerable daily intake of 12 µg/kg b.w. determined by WHO as part of their establishment of a drinking water guideline for nickel (WHO, 2005). See Fig. 11.4:2.

Lead
Inhalation exposure earlier contributed to a major part of the total Pb intake. The exposure to Pb has decreased drastically during the last decades, which is mainly due to the elimination of Pb in petrol. Concerning intake via food, EFSA have established a reference point, RP for adults, of 0.63 µg/kg b.w./day for chronic kidney disease, and a RP of 1.5 µg/kg b.w./day for effects on systolic blood pressure (EFSA, 2010). In children, EFSA has set a specific RP of 0.5 µg/kg b.w., based on neurotoxic effects. According to the present Swedish per capita intake of 0.083 µg/kg b.w./day there is a margin to the Pb RP (see Figure 11.4:2). While EFSA concludes that there is no evidence for a threshold for critical lead-induced effects, they consider that exposures below the RP are associated with a low risk for reduced intelligence quotient (IQ) levels in young children and for high blood pressure in adults.

11.4.7 Conclusion

According to the compilation in Figure 11.4:2, all of the studied toxic metal are below, or sometimes well below, their respective reference points. The metal with the smallest margin between estimated intake and its reference health value is cadmium (52% of TWI), and also for other metals these margins are relatively small. Because of the per

capita method used some individuals in the population will most likely have cadmium intakes clearly above the TWI. We are also aware of that new adverse effect findings may lead to future adjustments of TWI. In addition, the time trend increase in per capita intake of cadmium (Fig. 11.4:1) should be noted. Regarding arsenic, iAs is the main toxic arsenic species and data on iAs are needed and have indeed recently been produced. The per capita intake (MB 2010 + 2015 data) is below (20% of RP) the reference point for iAs. The two additional heavy metals, mercury and lead, have been studied for many years, and food contamination has been extensively studied. Even if their per capita intakes are below their RPs, consumers with certain habits (e.g. mercury: high fish intake) may result in a considerably increased intake of these metals. Consequently, a further lowering of the intake of these heavy metals is desirable. In case of aluminium, the per capita intake is low in comparison to its health RP but other exposure sources except for food must be taken into consideration. Nickel and silver have low per capita intakes in relation to their health RPs. Finally, exceeding of health RPs does not directly result in adverse health effects, but rather that the margin of safety will be smaller (see also General discussion).

11.5 Mycotoxins

11.5.1 Background

Mycotoxins are secondary metabolites from moulds which in small concentrations initiate a toxic response in vertebrates. Important mycotoxins to human health and trade are for examples the aflatoxins, ochratoxin A, deoxynivalenol (DON), zearalenone, fumonisins and patulin which are all regulated (Commission Regulation 1881/2006) but there are many hundreds of mycotoxins described (Bräse et al., 2009).

11.5.2 Chemical analysis

LC-MS/MS

Mycotoxins were analysed at National Food Agency, NFA, Sweden, in November 2016 in the two food groups cereals and fruit. The method used for all mycotoxins except patulin is a validated and accredited triple-quadropole-LC-MS/MS-method where the mycotoxins aflatoxin B1, B2, G1 and G2 (AB1, AB2, AG1, AG2), ochratoxin A (OTA), deoxynivalenol (DON), zearalenone (ZEA), T-2- and HT-2-toxin and fumonisin B1 and B2 (FB1, FB2) where analyzed in the same analysis. A portion of 25 g of the homogenized sample where used in the analysis. The sample extraction is performed by shaking with solvent followed by filtration. ^{13}C-isotope-marked internal standards where used in the MS-analysis for all mycotoxins analyzed. The results are corrected for the recovery found in recovery experiments analysed in parallel with the samples. The limit of quantification (LOQ), the lowest level of validation, of the method varies for the different mycotoxins between 0.3 and 100 µg/kg.

Patulin

Patulin (Pat) was analysed at NFA, Sweden, in November 2015 in the food group fruit. The method used for patulin is a validated but not accredited HPLC-UV-method. Patulin is extracted by gentle shaking with ethylacetate and sodium carbonate before HPLC-analysis. The LOQ of the method for patulin is 3 µg/kg.

11.5.3 Analytical results

In table 11.5:1 the results of the analysis of mycotoxins are presented, in relation to the individual LOQ levels. Mycotoxins in levels above the LOQ were not found in any of the samples analyzed. In order to obtain a basis for risk assessment, the background levels were also presented (Table 11.5:2). Although these levels are based on specific chromatographic peaks, the values are less exact and the substance identity cannot be fully guaranteed. The figures can only be used as a preliminary scenario for exposure assessment that should be more accurate as such than using ½LOQ or similar default values (see discussion in RCS, 2001). The quality of the exposure assessment must however be regarded in the light of the quality of input figures for food levels.

Table 11.5:1. Mycotoxin levels (µg/kg) in two food groups collected in the market basket study 2015; levels below LOQ not included

Food Group	Sample	Concentration in µg/kg											
		AB1	AB2	AG1	AG2	OTA	DON	ZEA	T2	HT2	FB1	FB2	Pat
Cereal	I:1	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	-
products	C:1	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	-
N=5	W:1	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	-
	CG:1	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	-
	L:1	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	-
Fruits	I:9	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	<3
N=5	C:9	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	<3
	W:9	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	<3
	CG:9	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	<3
	L:9	<0.5	<0.5	<0.5	<0.5	<0.3	<100	<5	<5	<5	<100	<100	<3

Table 11.5:2. Mycotoxin levels (µg/kg) in two food groups collected in the Market Basket study 2015; instrument levels presented regardless of LOQ. Data used in exposure assessment of analyzed mycotoxins

Food Group	Sample	Concentration in µg/kg*											
		AB1	AB2	AG1	AG2	OTA	DON	ZEA	T2	HT2	FB1	FB2	Pat
Cereal	I:1	0.02	0.01	0.00	0.00	0.10	38	3.4	0.48	1.5	6.3	7.6	-
products	C:1	0.02	0.02	0.00	0.00	0.09	21	3.3	0.44	0.9	4.1	1.8	-
N=5	W:1	0.01	0.02	0.00	0.01	0.19	52	3.8	0.33	1.4	1.1	0.90	-
	CG:1	0.01	0.02	0.00	0.00	0.12	50	3.5	0.29	1.2	0.68	0.31	-
	L:1	0.12	0.02	0.00	0.00	0.08	41	3.2	0.43	1.3	7.8	3.6	-
Fruits	I:9	0.01	0.00	0.00	0.29	0.05	8.0	3.7	0.46	1.6	0.85	0.00	0.00
N=5	C:9	0.01	0.00	0.00	0.02	0.09	8.2	4.6	0.34	1.0	0.00	0.10	0.00
	W:9	0.01	0.01	0.00	0.09	0.03	8.7	3.8	0.77	1.9	0.00	0.00	0.00
	CG:9	0.01	0.00	0.00	0.19	0.09	9.0	3.5	1.2	2.1	0.91	0.09	2.9
	L:9	0.01	0.01	0.00	0.12	0.19	8.1	3.4	0.54	1.8	0.00	0.00	0.00

* Levels below LOQ are often not presented, as they are less reliable compared to levels above LOQ. However, as a basis for exposure assessment instrument levels are preferred before using e.g. ½LOQ (RCS, 2001; Bergstrand and Karlsson, 2009)

11.5.4 Exposure estimation

The exposure assessments for the respective food group and mycotoxin are shown below in Table 11.5:3. The estimated daily total intake of the mycotoxin is also expressed as percentage of the current established tolerable daily intake (TDI) established by EFSA. Since the TDI for T-2 and HT-2 toxins and for fumonisins are group TDIs the exposure for these two groups of mycotoxins are shown as the sum of the toxins included in the group TDI. For comparison the last intake calculations, made from surveillance data and consumption data by NFA in 2009 or EFSA in more recent years, are also presented in the table. These calculations by NFA and EFSA show also the high exposure estimates (95^{th} percentile). In the present exposure assessments presented in Table 11.5:3 an

average body weight of 70 kg has been used to be in line with the body weight used in the exposure assessments in NFA (2009) and recommendations by EFSA (2012b).

The intake of patulin was not calculated since there was only one sample with measurable level.

The results from the different exposure assessment of mycotoxins from the market basket data are in surprisingly good agreement with the assessment of the average intake made earlier by NFA or EFSA. Considering that mycotoxins usually are very heterogeneously distributed in food one would expect that the market basket data underestimates the exposure. However, these results showed only a minor difference between the assessments.

Table 11.5:3. Average daily intake of mycotoxins from two different food categories (cereals and fruit) based on MB 2015 and compared with other exposure assessments.

	Market basket 2015				**Other exposure assessments**		
Mycotoxin	**Daily intake** (ng/kg bw[a]) **Cereals**	**Fruit**	**Total intake** (ng/kg bw)	**% of TDI**	**NFA 2009** (average-95:e percentil) (ng/kg bw)	**EFSA** (year) based on data from SE or EU (ng/kg bw)	**Comments**
Ochratoxin A	0.4	0.3	0.7	4.0	0.9-1.1	1.4-3.0[b] (2006)	
Zearalenone	11	13	24	10	-	2.4-29[c] 4.7-54[d] (2011)	
Deoxynivalenol	133	28	161	16	120-185	260-450 370-630 (2013)	NFA HBM: 84-5443 ng/kg bw[f]
T-2 och HT-2	5.4	7.9	13	13	2-14	3.4-18 7.2-39 (2013)	
Fumonisins B1+B2	22	1.3	24	1.2	20-60	50-630 90-1250 (2014)	
Aflatoxin B1	0.12	0.04	0.16	No TDI	0.2-0.6	-	Genotoxic carcinogen
Aflatoxin total	0.18	0.52	0.71	No TDI	-	0.69 (F) - 1.93 (B)[e] (2012)	

[a]body weight 70 kg
[b]average – 95th percentile
[c]average minimum LB (lower bound) to maximum UB (upper bound)
[d]95th percentile minimum LB to maximum UB
[e]GEMS Food cluster B, E and F (Europe)
[f]Human biomonitoring data (HBM) median – maximum value (Wallin et al., 2013)

The most unexpected results from the study are the exposures of zearalenone and trichotecenes T-2 and HT-2 toxins from the fruit group which are higher than from cereals. These toxins are produced by *Fusarium* species which are traditionally associated with cereal grain. However, in recent years reports on zearalenone and T-2/HT-2 in nuts and dried fruit reveal that this food group, which includes also nuts, may be an significant source of exposure of these toxins (Schollenberger et al., 2005; Trucksess and Scott, 2008; Tang et al., 2015).

11.5.5 Risk assessment

The average exposures for mycotoxins are generally low in the Swedish population according to the results of the Market basket 2015 and this result is in agreement with earlier assessments. However, the calculations do not include high consumers (95^{th} percentile) which the EFSA calculations do and their assessments show that a few percentage of the population may exceed the TDI for some of the mycotoxins (Table 11.5:4). The TDIs (EFSA, 2006, 2009c, 2011a, 2011b, 2014) are presented in Table 11.5:4. Human biomonitoring data of deoxynivalenol also indicate that around 1 % of the population have an intake above TDI but are in general low (Wallin et al., 2013).

Aflatoxins are among the most potent mutagenic and carcinogenic substances known (JECFA, 2016) and thus do not have an established TDI. The average intake of aflatoxin B_1 calculated in this MB study was almost identical to the intake estimate made in 2009 (NFA, 2009). That intake was estimated to contribute to maximum 3 aflatoxin-induced cancers per year in the Swedish population.

Table 11.5:4. TDI according to EFSA (expressed as ng/kg bw and day)

Mycotoxin	TDI (ng/kg bw day)
Ochratoxin A	17
Zearalenone	250
Deoxynivalenol	1000
T-2+HT-2	100
Fumonisin B1-B3	2000
Patulin	400*

*JECFA evaluation (1995) adopted by SCF, European Commission

11.5.6 Conclusion

This was the first time that mycotoxins were included in the Market basket studies performed by NFA. The results and the correlation to other exposure assessments indicate that this kind of study may be a valuable tool to follow the time trends of exposure for mycotoxins in the general population. According to the MB calculations, of the analysed mycotoxin DON showed the highest intake in relation to TDI limit (16% of TDI). However, when using a multi-mycotoxin analytical method you lose sensitivity and in this study the calculations are made on data which are below LOQ of the method. This adds to the uncertainty of the results. On the other hand, there are today multi-mycotoxin methods including hundreds of mycotoxins (Malachova et al., 2014) which may give even more information and not only on the regulated mycotoxins.

Moreover, mycotoxins can be found in a wide range of food groups and some important sources such as pulses, vegetables, oil seeds, milk and milk products, beverages such as beer, wine and coffee are missed in the calculation of risk since only two food groups (cereals and fruit)have been analysed..

11.6 PCBs /dioxins

11.6.1 Background

Polychlorinated biphenyls (PCBs), dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) are persistent and lipophilic substances that have the propensity to bioaccumulate in animals and biomagnify in aquatic food webs. They are ubiquitously spread in the environment and are found both in wildlife, animals in food production and in humans (Bernes, 1998). PCBs have been widely used in industry as e.g. heat exchange fluids, in electric transformers and as additives in paint and plastic. The production and use of chlorinated pesticides and PCBs have in most cases been strongly controlled or prohibited since the 1970s. PCDD/Fs are formed in certain chemical processes and during incomplete combustion (Bernes, 1998).

11.6.2 Chemical analysis

Dioxins (PCDD/Fs) and PCBs were analysed in selected food groups mainly contributing to exposure of persistent organic pollutants (POPs), i.e. eggs, fats/oils, fish/fish products, meat/meat products and dairy products (liquid and solid). One sample per food group and basket was analysed. Two of the fish baskets were analyzed both as fresh and cooked samples. This resulted in 32 samples for PCDD/F and PCB analysis.

The analysis of PCDD/Fs and PCBs was performed at the NFA, Sweden. The 17 toxic 2,3,7,8-chloro-substituted PCDD/Fs, 12 dioxin-like PCBs (DL PCBs; CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) and six non dioxin-like (NDL PCBs; CB 28, 52, 101, 138, 153, 180) were analysed. The samples of liquid dairy products were treated with a solution of potassium oxalate (35% in water) and ethanol and then extracted with liquid-liquid extraction using diethyl ether and *n*-pentane (1:1.4). The other food groups were extracted by pressurized liquid extraction (PLE) using a system from from Fluid Management Systems (MA, USA). A mixture of ethanol and toluene (7:3) was used for the extraction of meat/meat products and the other matrices were extracted with a mixture of pentane and actetone (7:3). Two extraction cycles of 20 minutes, the temperature 100℃ and the pressure 1500 psi were applied. The extracts were dried using sodium sulphate, followed by evaporation of the solvent and gravimetric lipid weight determination. Lipid removal, clean-up and fractionations were performed with a PowerPrep^{TM}-system from Fluid Management Systems (MA, USA). The final determination was performed using a GC-HRMS (Agilent Technologies 7980 GC and an AutoSpec Premier, Waters) with isotopic dilution technique. The NDL PCBs were injected on a HT8 column with a split/splittless injector in splittless mode. The DL PCBs and PCDD/Fs were injected on a DB5-MS UI or a Rtx-Dioxin2 column with a PTV injector in solvent vent mode. When the Rtx-Dioxin2 column was used CB 123 was quantified on the HT8 column. The HRMS was operated in EI mode, using single ion monitoring (SIM) at the resolution of 10 000. The limit of quantification varied between samples and was determined for the individual congeners in each sample.

^{13}C-labelled surrogate standards for all congeners were added to the sample before extraction. A number of control samples were analysed together with the samples to verify the accuracy and precision of the measurements. The trueness of the method has also been proven by participating in proficiency tests. The laboratory is accredited for the analysis of the liquid dairy samples.

11.6.3 Analytical results

The results from the analysis of PCDD/Fs and PCBs are presented in Tables 11.6:1-3. The PCDD/F and DL PCB levels are expressed as toxic equivalents (TEQ) using the toxic equivalency factors (TEF) set by WHO in 2005 (van den Berg et al., 2006). The levels below LOQ are set to either 0 i.e. lower bound (LB), to half the LOQ, i.e. medium bound (MB) or to the LOQ value, i.e. upper bound (UB).

The highest levels of PCDD/Fs and PCBs were found in fish. Some egg samples showed high levels of DL PCBs resulting in high PCDD/F/PCB-TEQ values and the variation in levels between samples was large. However, the levels of NDL PCBs were low in the egg samples.

Table 11.6:1. Levels of PCDD/F and PCB in food homogenates of selected market basket food groups. Levels are given in fresh weight and values are presented as upper bound (UB) levels.

Food groups	Sample		pg TEQ_{2005}/g			pg/g	
		Fat %	PCDD/F[1]	PCB[2]	PCDD/F/PCB[3]	Indicator-PCB[4]	CB 153
Eggs	C:6	8.66	0.058	0.017	0.075	77	12
	CG:6	8.73	0.050	0.042	0.092	218	83.0
	I:6	7.90	0.10	0.27	0.37	67	11
	L:6	8.07	0.054	0.24	0.29	89	24.6
	W:6	8.87	0.063	0.27	0.33	62	12
Fish	C:4	12.0	0.11	0.18	0.29	2130	804
	CG:4	8.33	0.11	0.16	0.27	1860	672
	I:4	11.1	0.10	0.17	0.27	2040	734
	L:4	11.6	0.13	0.19	0.32	2300	803
	W:4	10.5	0.13	0.21	0.34	2210	808
Meat	C:3	8.40	0.017	0.011	0.028	83	29.8
	CG:3	11.1	0.022	0.015	0.036	100	34.4
	I:3	12.9	0.021	0.013	0.034	87	32.8
	L:3	11.1	0.017	0.021	0.038	165	64.0
	W:3	10.9	0.018	0.013	0.031	88	33.9
Dairy prod. liquids	C:5A	1.80	0.0039	0.0037	0.0075	19	7.07
	CG:5A	1.61	0.0047	0.0041	0.0088	18	6.96
	I:5A	1.61	0.0031	0.0036	0.0067	17	6.30
	L:5A	1.70	0.0046	0.0034	0.0080	17	6.43
	W:5A	1.48	0.0040	0.0031	0.0071	17	6.36
Diary prod. solids	C:5B	25.3	0.035	0.049	0.084	239	90.3
	CG:5B	24.7	0.039	0.048	0.087	228	83.9
	I:5B	23.1	0.037	0.054	0.091	245	87.3
	L:5B	25.4	0.035	0.056	0.09	271	106
	W:5B	25.7	0.026	0.042	0.068	194	70.6

Food groups	Sample		pg TEQ_{2005}/g			pg/g	
		Fat %	PCDD/F[1]	PCB[2]	PCDD/F/PCB[3]	Indicator-PCB[4]	CB 153
Fats, oils	C:7	62.1	0.057	0.032	0.088	263	63.0
	CG:7	64.6	0.054	0.039	0.093	300	71.2
	I:7	62.8	0.054	0.035	0.089	272	66.7
	L:7	64.6	0.093	0.054	0.15	361	90.8
	W:7	61.5	0.069	0.047	0.12	371	96.0

[1] Sum TEQ of 17 PCDD/F congeners.
[2] Sum TEQ of 12 dioxin-like PCB congeners (CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)
[3] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.
[4] Sum of six non dioxin-like PCB congeners, i.e indicator-PCB (CB 28, 52, 101, 138, 153, 180).

Table 11.6:2. Levels of PCDD/F and PCB in food homogenates of selected market basket food groups. Levels are given in fresh weight and values are presented as medium bound (MB) levels.

Food groups	Sample		pg TEQ_{2005}/g			pg/g	
		Fat %	PCDD/F[1]	PCB[2]	PCDD/F/PCB[3]	Indicator-PCB[4]	CB 153
Eggs	C:6	8.66	0.029	0.0083	0.037	39	6
	CG:6	8.73	0.031	0.022	0.053	188	83.0
	I:6	7.90	0.051	0.27	0.32	33	5.5
	L:6	8.07	0.027	0.24	0.26	70	24.6
	W:6	8.87	0.033	0.27	0.30	31	6
Fish	C:4	12.0	0.11	0.18	0.29	2130	804
	CG:4	8.33	0.11	0.16	0.27	1860	672
	I:4	11.1	0.095	0.17	0.27	2040	734
	L:4	11.6	0.12	0.19	0.31	2300	803
	W:4	10.5	0.13	0.21	0.34	2210	808
Meat	C:3	8.40	0.0084	0.011	0.02	73	29.8
	CG:3	11.1	0.011	0.015	0.026	89	34.4
	I:3	12.9	0.010	0.013	0.024	79	32.8
	L:3	11.1	0.0085	0.021	0.03	155	64.0
	W:3	10.9	0.009	0.013	0.022	80	33.9
Dairy prod. liquids	C:5A	1.80	0.0019	0.0037	0.0056	17	7.07
	CG:5A	1.61	0.0024	0.0041	0.0065	17	6.96
	I:5A	1.61	0.0016	0.0036	0.0051	16	6.3
	L:5A	1.70	0.0023	0.0034	0.0057	16	6.43
	W:5A	1.48	0.0020	0.0031	0.0051	16	6.36
Diary prod. solids	C:5B	25.3	0.027	0.026	0.054	219	90.3
	CG:5B	24.7	0.035	0.048	0.083	208	83.9
	I:5B	23.1	0.028	0.054	0.082	215	87.3
	L:5B	25.4	0.026	0.056	0.082	251	106
	W:5B	25.7	0.024	0.042	0.066	174	70.6
Fats, oils	C:7	62.1	0.036	0.031	0.066	202	63.0
	CG:7	64.6	0.038	0.038	0.076	230	71.2
	I:7	62.8	0.034	0.034	0.068	201	66.7
	L:7	64.6	0.084	0.053	0.14	276	90.8
	W:7	61.5	0.046	0.046	0.092	286	96.0

[1] Sum TEQ of 17 PCDD/F congeners.
[2] Sum TEQ of 12 dioxin-like PCB congeners (CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)
[3] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.

[4] Sum of six non dioxin-like PCB congeners, i.e indicator-PCB (CB 28, 52, 101, 138, 153, 180).

Table 11.6:3. Levels of PCDD/F and PCB in food homogenates of selected market basket food groups. Levels are given in fresh weight and values are presented as lower bound (LB) levels.

Food groups	Sample		pg TEQ_{2005}/g			pg/g	
		Fat %	PCDD/F[1]	PCB[2]	PCDD/F/PCB[3]	Indicator-PCB[4]	CB 153
Eggs	C:6	8.66	0	0	0	0	0
	CG:6	8.73	0.011	0.002	0.013	158	83.0
	I:6	7.90	0.002	0.27	0.27	0	0
	L:6	8.07	0	0.24	0.24	49	24.6
	W:6	8.87	0.0026	0.27	0.27	0	0
Fish	C:4	12.0	0.11	0.18	0.29	2130	804
	CG:4	8.33	0.1	0.16	0.27	1860	672
	I:4	11.1	0.089	0.17	0.26	2040	734
	L:4	11.6	0.12	0.19	0.31	2300	803
	W:4	10.5	0.13	0.21	0.34	2210	808
Meat	C:3	8.40	0	0.011	0.011	64	29.8
	CG:3	11.1	0	0.015	0.015	79	34.4
	I:3	12.9	0	0.013	0.013	71	32.8
	L:3	11.1	0	0.021	0.021	155	64.0
	W:3	10.9	0	0.013	0.013	72	33.9
Dairy prod. liquids	C:5A	1.80	0.000029	0.0037	0.0037	15	7.07
	CG:5A	1.61	0.00012	0.0041	0.0042	15	6.96
	I:5A	1.61	0.000035	0.0036	0.0036	15	6.30
	L:5A	1.70	0.000029	0.0034	0.0034	14	6.43
	W:5A	1.48	0.000031	0.0031	0.0032	14	6.36
Diary prod. solids	C:5B	25.3	0.020	0.0039	0.024	189	90.3
	CG:5B	24.7	0.031	0.048	0.079	178	83.9
	I:5B	23.1	0.019	0.054	0.073	185	87.3
	L:5B	25.4	0.017	0.056	0.073	231	106
	W:5B	25.7	0.022	0.042	0.064	154	70.6
Fats, oils	C:7	62.1	0.015	0.03	0.044	140	63.0
	CG:7	64.6	0.021	0.037	0.058	150	71.2
	I:7	62.8	0.014	0.033	0.047	140	66.7
	L:7	64.6	0.076	0.052	0.13	190	90.8
	W:7	61.5	0.023	0.045	0.068	210	96.0

[1] Sum TEQ of 17 PCDD/F congeners.
[2] Sum TEQ of 12 dioxin-like PCB congeners (CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)
[3] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.
[4] Sum of six non dioxin-like PCB congeners, i.e indicator-PCB (CB 28, 52, 101, 138, 153, 180).

Table 11.6:4. Mean levels of PCDD/F and PCB in food homogenates of selected market basket food groups. Levels are given in fresh weight and mean values are presented as medium bound (MB), lower bound (LB) and upper bound (UB). Number (N) of samples analysed per each food group.

Food groups			pg TEQ_{2005}/g			pg/g	
		Fat %	PCDD/F[1]	PCB[2]	PCDD/F/PCB[3]	Indicator-PCB[4]	CB 153
Egg	Mean MB	8.45	0.0342	0.162	0.194	72.2	25.0
N=5	Mean LB		0.0031	0.156	0.159	41.4	21.5
	Mean UB		0.065	0.168	0.231	103	28.5
Fish	Mean MB	10.7	0.113	0.182	0.296	2110	764
N=5	Mean LB		0.110	0.182	0.294	2110	764
	Mean UB		0.116	0.182	0.298	2110	764
Meat	Mean MB	10.9	0.00938	0.0146	0.0244	95.2	39.0
N=5	Mean LB		0	0.0146	0.0146	88.2	39.0
	Mean UB		0.019	0.0146	0.0334	105	39.0
Diary prod. Liquids	Mean MB	1.64	0.00204	0.00358	0.0056	16.4	6.62
N=5	Mean LB		0.00005	0.00358	0.00362	14.6	6.62
	Mean UB		0.00406	0.00358	0.00762	17.6	6.62
Dairy prod. Solids	Mean MB	24.8	0.0280	0.0452	0.0734	213	87.6
N=5	Mean LB		0.0218	0.0408	0.0626	187	87.6
	Mean UB		0.0344	0.0498	0.0840	235	87.6
Fats, oils	Mean MB	63.1	0.0480	0.0404	0.0884	239	77.5
N=5	Mean LB		0.0298	0.0394	0.0698	166	77.5
	Mean UB		0.0654	0.0414	0.108	313	77.5

[1] Sum TEQ of 17 PCDD/F congeners.
[2] Sum TEQ of 12 dioxin-like PCB congeners (CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189)
[3] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.
[4] Sum of six non dioxin-like PCB congeners, i.e indicator-PCB (CB 28, 52, 101, 138, 153, 180).

11.6.4 Exposure estimation, time trends

The non-dioxinlike (NDL) PCB congener CB 153 was used as a marker for total PCB in the market basket study. In the 2010 market basket study CB 153 contributed with about 20 % to the per capita intake total PCB (28 congeners) (NFA, 2012) and per capita intake of CB 153 was strongly correlated with total PCB intake (Pearson´s $r=0.96$, $p<0.001$, $N=9$). In 2015 total per capita intake of both CB 153 and PCDD/F/PCB TEQ varied less than 2-fold between individual food chain baskets (Table 11.6:5), showing a homogenous contamination pattern on the Swedish food market. For CB 153 most of the individual food group baskets had concentrations higher than LOQ, giving almost identical lower- and upper-bound total per capita intakes. In the case of PCDD/Fs and DL PCBs there were some congeners with a large proportion of concentrations below LOQ. As a consequence the lower- and upper-bound total per capita intakes differed more than 30%.

Table 11.6:5. Per capita intake of CB 153 (ng/day) and PCDD/F/PCB TEQ (pg/day) in 2015 (median (range)).

Compounds	Intake
PCDD/F/PCB TEQ_{2005}	
Lower-bound	30 (19-37)
Medium-bond	36 (26-41)
Upper-bound	41 (32-45)
CB 153	
Lower-bound	55 (52-66)
Medium-bond	56 (52-66
Upper-bound	56 (52-66)

N=5. ∑PCDD/F /PCB TEQ=sum TEQ of 17 PCDD/Fs and 12 dioxinlike PCBs using WHO2005 toxicity equivalent factors.

The most obvious differences in food group contribution to total per capita intake of CB 153 and PCDD/F/PCB TEQ were observed for eggs and fish. For CB 153 fish contributed >60% to the total per capita intake and 40% to the PCDD/F/PCB TEQ intake (Table 11.6:6). Eggs gave a small contribution to CB 153 intake (<1%) but contributed over 15% to the intake of PCDD/F/PCB TEQ, suggesting differences in contamination patterns between the two compound groups. The egg baskets showed the highest variation in contribution between food chain baskets with a 15-fold variation for CB 153 and a 6-fold variation for PCDD/F/PCB TEQ (Table 11.6:6). The reason for this large variation in contamination of egg baskets may be due to inclusion of eggs contaminated in an isolated incident of high PCDD/F/PCB levels in hen´s feed, or an inclusion of eggs from an egg-producing facility with high PCDD/F/PCB contamination in the environment of the hens. Also in the 2010 MB study a large variation in the contamination of egg baskets was observed (NFA, 2012).

Table 11.6:6. Median contribution (range) of the different food groups to the total per capita intake (medium-bound) of PCBs and PCDD/Fs.

Compounds	Fish (%)	Meat (%)	Dairy (%)	Eggs (%)	Fats (%)
CB-153	64 (56-66)	13 (11-21)	13 (10-13)	0.30 (0.29-4.4)	6.1 (5.1-7.7)
PCDD/F/PCB TEQ_{2005}	41 (34-51)	16 (12-19)	17 (14-22)	18 (4.0-25)	12 (8.5-16)

N=5-9

Log-linear regression analysis was used to investigate temporal trends of total per capita intake CB 153 and toxicity equivalents (TEQ_{1998}) of PCDD/F and dioxin-like PCBs 1999-2015 (Fig. 11.6:1). When PCB and PCDD/F concentrations in the food samples were below the limit of quantification (LOQ) the concentrations were set to ½ LOQ. In 1999 per capita intake was estimated for four major cities in Sweden (Malmö, Göteborg, Uppsala, Sundsvall, N=4), based on purchases from two food chains in each city. In 2005 per capita intake was estimated separately for the two food chains in each city separately (N=8). In 2010 two baskets were purchased (low and normal priced baskets) in each of four food chains sampled in Uppsala, and one basket (low price) from one Uppsala food chain (N=9). In 2015 normal-priced baskets were purchased from five retail chains in Uppsala 2015 (N=5). Declining trends of total per capita intakes of CB 153 and PCDD/F/PCB TEQ_{1998} were observed between 1999 and 2015, with a mean decrease of 4.5% per year (Fig. 11.6:1). Declining temporal trends of non-dioxinlike PCBs and PCDD/F/PCB TEQs in mother´s milk from nursing women in Sweden since the early

1970s show that human exposure in Sweden has decreased for many decades after risk management efforts to minimize environmental pollution were introduced (Norén och Meironyté, 2000; Lignell et al., 2014).

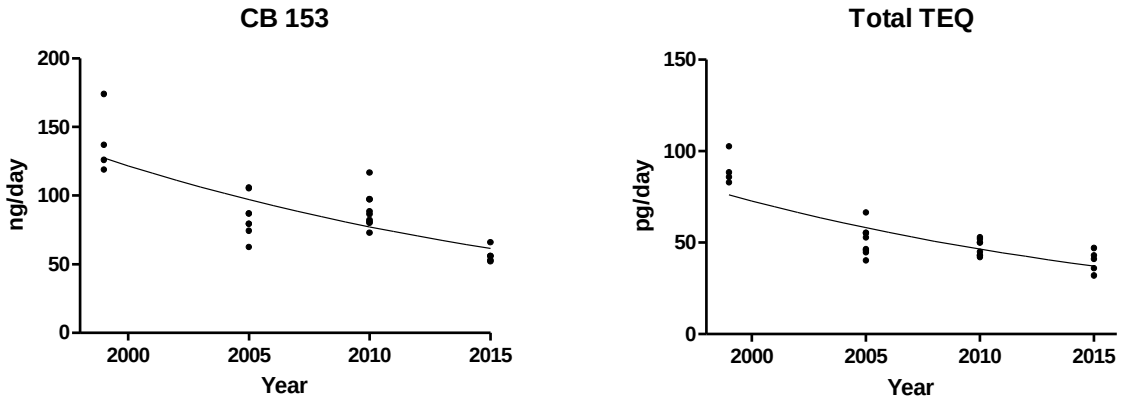


Figure. 11.6:1. Temporal trends of per capita intake of CB 153 and toxicity equivalents (TEQ_{1998}) of PCDD/Fs and DL PCBs (medium-bound) 1999-2015. Dots represents per capita intake estimated for 4 Swedish cities 1999 and 2005 (Malmö, Göteborg, Uppsala, Sundsvall), and for 5 food chains in Uppsala 2010 and 2015. The line represents the log-linear regression line. Due to the log transformation of per capita intakes, the linear regression coefficient gives the % change of per capita intake per year. CB 153 intake decreased 4.5% (mean; standard error: 0.74%; $p<0.001$) and total TEQ intake decreased 4.5% (SE: 0.64%, $p<0.001$). Trends were statistically significant (log-linear simple regression analysis, $p\leq0.05$, N=26).

11.6.5 Effect of cooking

Two fish baskets were analysed as fresh and cooked and the results are presented in Table 11.6:7. The differences in levels between fresh and cooked samples are small showing that the cooking did not affect the levels significantly.

Table 11.6:7. Effect of cooking on levels of PCDD/F and PCB in two samples of fish/fish products. Levels are given in fresh weight and values are presented as lower bound (LB), medium bound (MB) and upper bound (UB).

Sample	Preparation		pg TEQ_{2005}/g			pg/g	
		Fat %	**PCDD/F[1]**	**PCB[2]**	**PCDD/F/PCB[3]**	**Indicator-PCB[4]**	**CB 153**
CG:4 (UB)	Fresh	8.33	0.11	0.16	0.27	1860	672
CG:4 (MB)	Fresh		0.11	0.16	0.27	1860	672
CG:4 (LB)	Fresh		0.10	0.16	0.27	1860	672
CG:4 (UB)	Cooked	8.54	0.11	0.19	0.30	1930	710
CG:4 (MB)	Cooked		0.10	0.19	0.29	1930	710
CG:4 (LB)	Cooked		0.094	0.19	0.28	1930	710
W:4 (UB)	Fresh	10.5	0.13	0.21	0.34	2210	808
W:4 (MB)	Fresh		0.13	0.21	0.34	2210	808
W:4 (LB)	Fresh		0.13	0.21	0.34	2210	808
W:4 (UB)	Cooked	11.2	0.15	0.25	0.40	2470	898
W:4 (MB)	Cooked		0.14	0.25	0.40	2470	898
W:4 (LB)	Cooked		0.14	0.25	0.39	2470	898

[1] Sum TEQ of 17 PCDD/F congeners.
[2] Sum TEQ of 12 dioxin-like PCB congeners (CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189).
[3] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.
[4] Sum of six non dioxin-like PCB congeners, i.e indicator-PCB (CB 28, 52, 101, 138, 153, 180).

The per capita intake of PCDD/F/PCB TEQ from fresh fish from one food basket was 12.4 pg/d, and 12.8 pg/day when cooked. The corresponding intakes for fish from the same, but un-cooked, basket were slightly higher (16 pg/day and 17 pg/day). For CB 153 per capita intake did not change markedly, since per capita intake for the fresh baskets were 31 and 37 ng TEQ/day and the corresponding intakes for cooked fish baskets 31 and 35 ng/day. Taken together the results show that cooking of the fish baskets did not markedly change the per capita TEQ and PCB intakes from fish.

11.6.6 Risk assessment

In 2005 the CONTAM-panel of EFSA did a risk assessment of NDL PCBs in food (EFSA, 2005a). The panel did not decide on a tolerable intake of NDL PCB due to a limited toxicological database. However, no adverse exposure levels (NOAELs) of 30-40 µg NDL PCBs/kg body weight/day were observed in animal studies, with liver and thyroid toxicity as the most sensitive endpoints. It was pointed out that it could not be excluded that some of these effects could have been caused by contamination of the NDL PCBs with dioxins and/or DL PCBs. Using the per capita intake of CB 153 (Table 11.6:5) and a contribution of CB 153 intake to total PCB intake of 20%, the per capita intake of total PCB intake is estimated to 280 ng/day. With a body weight of 76.6 kg the total PCB intake is 3.7 ng/kg body weight/day. A worst case assessment suggests a margin of exposure between intakes at the NOAELs in the animal studies (30-40 µg/kg/day) and the per capita intake of total PCB in 2015 (0.004 µg PCB/kg body weight/day) of about 10 000. Even when using lower body weights the margins to NOAELs are large.

In 2001 the tolerable intake of PCDD/F and dl-PCBs was set to 14 pg TEQ/kg body weight/week by the EU Scientific Committee on Food (SCF, 2001). This corresponds to a daily intake of approximately 2 pg TEQ/kg body weight/day. This tolerable intake was

based on developmental effects of the most toxic dioxin congener TCDD in offspring of exposed female rats (SCF, 2001; JECFA, 2001). Consequently, the tolerable intake is relevant for girls and women of a child-bearing age that bioaccumulate the contaminants before pregnancy. Assuming an average body weight of 60 kg for young women the total per capita medium-bound intakes of PCDD/F/PCB TEQ in 2015 corresponds to 0.43-0.68 pg TEQ/kg body weight/day, which is 3-5 times lower than the SCF/WHO tolerable intake. For younger girls the difference between the per capita exposure and the tolerable intake is most probably lower than for adults due to the higher food consumption per kilo body weight. In 2012 US EPA published a reference dose (Rfd) for PCDD/F/PCB TEQ of 0.7 pg/kg body weight/day (US EPA, 2012). Rfd was based on studies from Seveso, Italy, where accidental high exposure to the most toxic PCDD/F/dioxin-like PCB TCDD occurred after an industrial accident. The most sensitive TCDD effects observed were alterations of thyroid hormone levels in newborns to mothers exposed before pregnancy and decreased sperm quality among men exposed after birth but before puberty (US EPA, 2012). The total per capita intake of PCDD/F/PCB TEQ in 2015 of 0.43-0.68 pg TEQ/kg body weight for young women (60 kg) is below or at the same level as the Rfd. For children and adolescents with lower body weights the Rfd is exceeded.

There is no internationally established health-based tolerable intake of PCDD/F/PCB TEQ that is relevant for adolescents after puberty, men and women above childbearing age. Hanberg et al. (2007) proposed a tolerable TEQ intake range of 2-10 pg/kg body weight/day as intake levels that cause negligible health effects during non-developmental PCDD/F/PCB TEQ exposure. Cancer and immunological effects were the most sensitive endpoints in the animal studies used in the development of the tolerable intake range (Hanberg et al., 2007). The estimated total per capita intakes of PCDD/F/PCB TEQs in 2015 (0.34-0.53 pg/kg body weight/day) were lower than this proposed intake range using a body weight of 76.6 kg, and also if using a lower body weight for adolescents after puberty.

11.6.7 Conclusion

PCB 153 intake was used as a marker of total PCB intake. The most obvious differences in food group contribution to total per capita intake of PCBs and PCDD/F/PCB TEQs were contribution of eggs and fish. For PCBs fish contributed >60% to the total per capita intake and 40% to the PCDD/F/PCB TEQ intake. Eggs gave a small contribution to PCB intake, <1%, but contributed over 15% to the intake of PCDD/F/PCB TEQs, suggesting differences in contamination patterns between the two compound groups. Per capita consumption of PCBs and PCDD/F/PCB TEQs decreased with 4.5% per year between 1999 and 2015, showing positive results of the risk management efforts to reduce human exposure. If the average body weight for adults is used total per capita intake of PCDD/F/PCB TEQs is slightly lower than the reference dose published by US EPA in 2012. For women in child-bearing ages with lower body weight per capita intake is at the level of the reference dose. When using body weight for children and adolescents the US EPA reference dose is exceeded.

11.7 Organochlorinated pesticides

11.7.1 Background

Chlorinated pesticides (e. g. DDT, HCB, chlordanes) are persistent and lipophilic substances with the propensity to bioaccumulate in animals and biomagnify in aquatic food webs. As a result of their stability in the environment, high volume production, long time use, and long-range atmospheric transport they are ubiquitously spread in the environment and are found both in wildlife and humans (Bernes, 1998). DDT and chlordanes have been widely used as insecticides mainly in agriculture and DDT also in malaria control. Hexachlorobenzene (HCB) has been used as a fungicide but it is also formed unintentionally as a contaminant in chemical and combustion processes (Bernes, 1998). The use of these pesticides has been banned in Sweden for decades.

11.7.2 Chemical analysis

The analytical method used to analyse chlorinated pesticides; hexachlorobenzene (HCB), hexachlorocyclohexane (α-, β-, γ-HCHs), chlordanes (oxy-, α-, γ-chlordane and trans-nonachlor) and DDTs (o,p'-DDT, p,p'-DDT, p,p'-DDD and p,p'-DDE) has previously been described (Törnkvist et al., 2011). One sample of six different food groups and basket was analysed at NFA during spring and autumn 2016, resulting in a total of 30 samples. Only samples from food goups of animal origin were chosen, egg, fish, meat, diary products (liquid and solid), and fats and oils.

Briefly, food homogenates were extracted with a mixture of hexane/acetone and hexane/diethyl ether. The lipid content was determined gravimetrically after evaporation of the organic solvents. The extracts were redissolved in hexane and the lipids were removed by sulfuric acid treatment. Further cleanup was done on a silica gel column. O,p'-DDD was used as internal standard. The analytes were analysed on a gas chromatograph (Agilent Technologies 6890) equipped with dual columns and dual electron capture detectors (GC/ECD).

Analytical quality control
All glassware was heated or rinsed with acetone prior to use to minimize the risk of contamination. A number of solvent blanks and quality control samples were analysed together with the samples to verify the accurancy and precision of the measurements. LOQ varied depending on the matrix and the quantified analyte, ranging from 0.013 to 0.5 ng/g f.w. The method is accredited against ISO 17025 by SWEDAC for PCB and organic chlorinated pesticides in fish, milk and egg.
The trueness of the method is proven by participating in proficiency tests.

11.7.3 Analytical results

Mean values presented in Table 11.7:1 are calculated as medium bound levels (results below the limit of quantification (<LOQ) are set to half the LOQ value), as lower bound (results < LOQ are set to zero) or as upper bound (where results < LOQ are set to the LOQ value). In general, levels of chlorinated pesticides are low, in most cases below LOQ. The most frequently detected pesticides were p,p'-DDE and HCB, with the highest concentrations of 1.7 and 0.68 ng/g fresh weight, respectively, in the fish baskets. Fish was the food group containing detectable amounts of almost all the pesticides analysed

and had the highest sum mean medium bound (∑MB) concentrations, 3.5 ng/g fresh weight. Oxychlordane was only detected and quantified in fish and the MB levels renged between 0.063 and 0.086 ng/g f.w. (data not shown in table 11.7:1). Dairy product liquids had no detected levels of any of the analysed pesticides and are not reported in Table 11.7:1. Neither are α-HCH, γ-HCH, and o,p'-DDT as levels were below the detection limit in all samples analysed.

Table 11.7:1. Chlorinated pesticide levels in food homogenates of selected market basket food groups. Levels are given in ng/g fresh weight and mean values are presented as medium bound (MB), lower bound (LB) and upper bound (UB). Number (N) of samples analysed per each food group and number of results <LOQ are also reported.

Food groups		**Concentrations in ng/g f.w.**							
		Fat %	**HCB**	**p,p'-DDE**	**p,p'-DDT**	**α-chlordane**	**γ-chlordane**	**β-HCH**	**Trans-nonachlor**
Egg	Mean MB	10.9	0.031	0.035	0.013	0.006	0.006	0.006	0.010
N=5	Mean LB		0.031	0.028	0	0	0	0	0.005
	Mean UB		0.031	0.043	0.025	0.013	0.013	0.013	0.015
	<LOQ/all		0/5	3/5	5/5	5/5	5/5	5/5	4/5
Fish	Mean MB	11.0	0.571	1.37	0.240	0.282	0.033	0.045	0.365
N=5	Mean LB		0.571	1.37	0.240	0.282	0.013	0.035	0.365
	Mean UB		0.571	1.37	0.240	0.282	0.063	0.055	0.365
	<LOQ/all		0/5	0/5	0/5	0/5	4/5	2/5	0/5
Meat	Mean MB	12.6	0.075	0.115	0.013	0.006	0.006	0.006	0.006
N=5	Mean LB		0.075	0.115	0	0	0	0	0
	Mean UB		0.075	0.115	0.025	0.013	0.013	0.013	0.013
	<LOQ/all		0/5	0/5	5/5	5/5	5/5	5/5	5/5
Diary prod.,solids	Mean MB		0.312	0.394	0.016	0.006	0.006	0.042	0.006
N=5	Mean LB	25.5	0.312	0.394	0.006	0	0	0.042	0
	Mean UB		0.312	0.394	0.026	0.013	0.013	0.042	0.013
	<LOQ/all		0/5	0/5	4/5	5/5	5/5	0/5	5/5
Fats, oils	Mean MB	69.7	0.211	0.326	0.038	0.038	0.038	0.038	0.038
N=5	Mean LB		0.211	0.326	0	0	0	0	0
	Mean UB		0.211	0.326	0.075	0.075	0.075	0.075	0.075
	<LOQ/all		0/5	0/5	5/5	5/5	5/5	5/5	5/5

11.7.4 Exposure estimation, time trends

HCB and p,p'-DDE, which is the major DDT metabolite, were present at high enough concentrations in all food groups to allow for calculations of total per capita intakes (Table 11.7:2). The median total per capita intake of p,p'-DDE was 1.6-fold higher than the intake of HCB. Differences in intake between stores were small, less than 2-fold. When looking at individual food groups the largest intake variation was observed for p,p'-DDE in eggs (about 10-fold) (Table 11.7:2).

Table 11.7:2. Total per capita intake (medium-bound, ng/day) of p,p'-DDE and HCB in the 2015 Market Basket study (median (range), N=5).

Compounds	Fish	Meat	Dairy	Eggs	Fats	Total
p,p'-DDE	65 (48-78)	19 (13-51)	39 (33-47)	0.35 (0.35-2.6)	7.8 (6.1-42)	134 (110-206)
HCB	26 (23-31)	15 (14-21)	32 (29-33)	0.72 (0.50-1.5)	10 (9.1-10)	82 (77-88)

Fish consumption gave the largest contribution to the total intake of p,p'-DDE followed by dairy and meat products (Table 11.7:3). HCB showed a slightly different contamination pattern, with dairy products giving the largest contribution followed by fish and meat, suggesting that contamination pathways in the food production chain differ between p,p'-DDE and HCB.

Table 11.7:3. Median contribution (range, N=5) of the different food groups to the total per capita intake (medium-bound) of p,p'-DDE and HCB.

Compounds	Meat (%)	Fish (%)	Dairy (%)	Eggs (%)	Fats (%)
p,p'-DDE	16 (11-17)	44 (31-58)	27 (23-39)	0.31 (0.26-1.8)	5.7 (5.4-20)
HCB	18 (16-24)	31 (26-35)	37 (37-39)	0.92 (0.61-1.0)	12 (11-12)

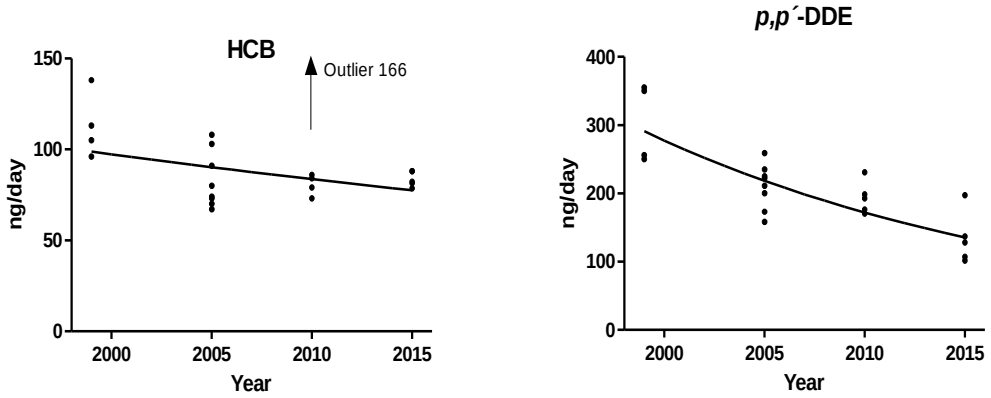


Figure 11.7:1. Temporal trends of total per capita intake of HCB and p,p'-DDE in Sweden 1999-2015. The line represents the log-linear regression line. Due to the log transformation of per capita intakes, the linear regression coefficient gives the % change of per capita intake per year. For HCB the mean decline in intake was estimated to 1.5% per year (standard error: 0.64%, p=0.030, N=21) when an outlier in 2010 was excluded, and for p,p'-DDE 4.8% (0.74%, p<0.001, N=22).

Log-linear regression analysis was used to investigate temporal trends of total per capita intake of p,p'-DDE and HCB 1999-2015 (Fig. 11.7:1). In 1999 per capita intake was estimated for four major cities in Sweden (Malmö, Göteborg, Uppsala, Sundsvall, N=4), based on purchases from two food chains in each city. In 2005 per capita intake was estimated separately for the two food chains in each city separately (N=8). In 2010 two baskets were purchased (low and normal priced baskets) in each of four food chains sampled in Uppsala, and one basket (low price) from one Uppsala food chain (N=9). In 2015 normal-priced baskets were purchased from five retail chains in Uppsala 2015 (N=5). Temporal trend analyses of total per capita intake of p,p'-DDE and HCB show decreasing trends of both p,p'-DDE and HCB (Fig. 11.7:1). For HCB the trend was obvious after exclusion of an outlier in 2010 with a high HCB concentration in the meat basket (NFA, 2012). The trend was slower for HCB than for p,p'-DDE. There is only one source of p,p'-DDE contamination of the environment and that is use of DDT as a pesticide, which has been banned in most areas of the world for a long time. For HCB other sources than use as a pesticide is evident, for instance un-intentional production during combustion processes and as a by-product in production of chlorinated chemicals (Bernes, 1998). It may be hypothesized that this multi-source contamination of the environment at least partly may explain the slower decrease of total per capita intake of HCB. Decreasing p,p'-DDE and HCB exposure of the consumers in Sweden is supported by decreasing body burdens of the compounds among pregnant and nursing women between 1996 and 2012 (Lignell et al., 2014).

Other chlorinated pesticides/metabolites analysed, apart from p,p'-DDE and HCB, were only measured in the fish baskets, since earlier studies in 1999 and 2005 showed that concentrations were generally below LOQ in other food group baskets. A trend analysis of pesticide/metabolite per capita intake from the fish baskets showed decreasing trends between 1999 and 2015 for p,p'-DDD, α-chlordane, oxy-chordane, and trans-nonachlor, with mean declines of around 4% per year (Fig. 11.7:2). This shows that the general

pollution of the aquatic food production chain is decreasing. An exception is p,p'-DDT, the main component of the technical DDT-mixture, which did not show a statistically significant temporal trend (Fig. 11.7:2). One factor to consider in the trend analyses of per capita intake from fish is that the per capita fish consumption has increased between 1999 and 2015.

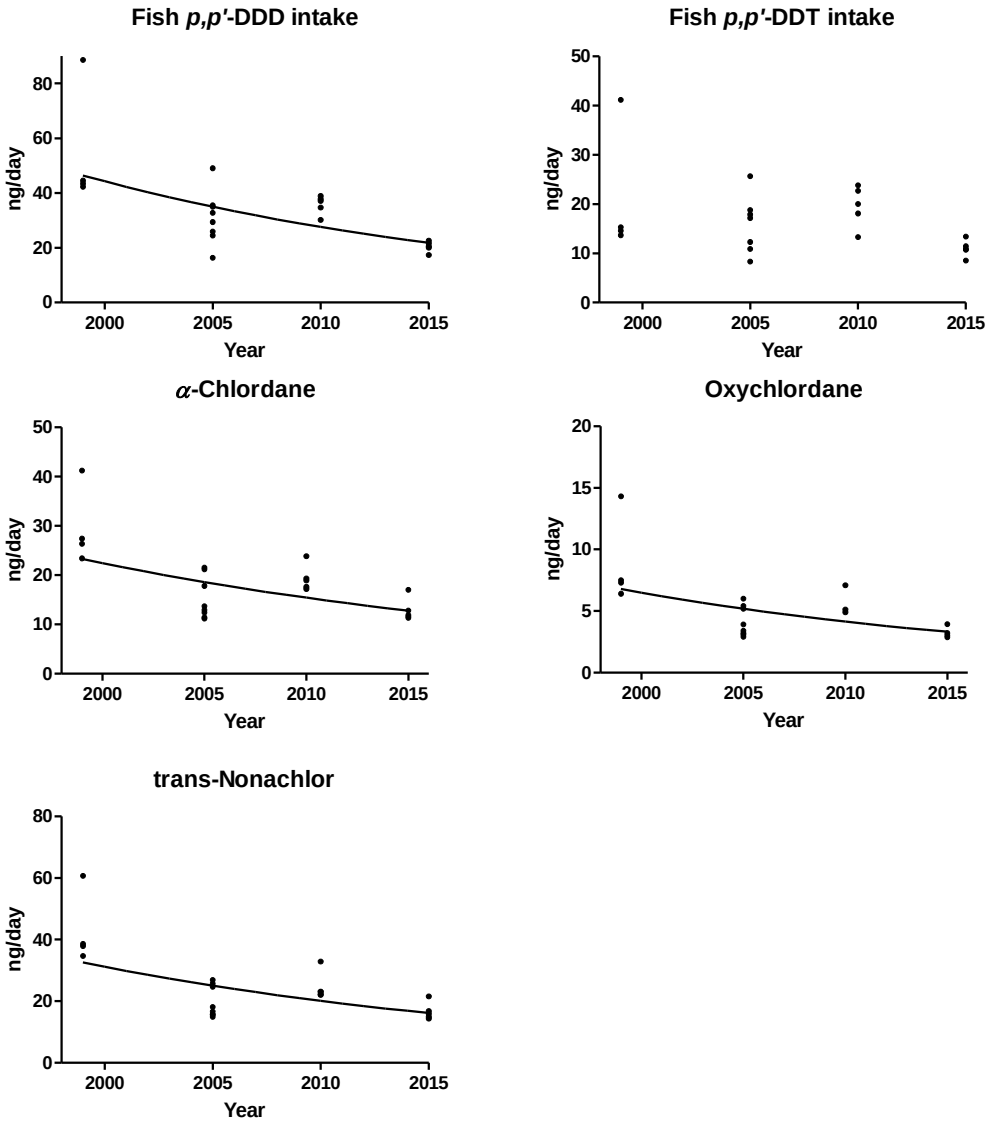


Figure 11.7:2. Temporal trend of per capita intake of chlorinated pesticides/metabolites in Sweden 1999-2015. In 2010 and 2015 intake was estimeated from data for 5 food retail chains in Uppsala The line represents the log-linear regression line. Due to the log transformation of per capita intakes, the linear regression coefficient gives the % change of per capita intake per year. For p,p'-DDD the mean decline in intake was estimated to 4.7% per year (standard error: 1.2%, p=0.001), for p,p'-DDT no significant trend was observed (p=0.082), for α-chlordane intake declined 3.7% (1.1%, p=0.004) per year, oxychlordane 4.5% (1.3%, p=0.002) and trans-nonachlor 4.4% (1.2%, p=0.001).

11.7.4 Risk assessment

A provisional acceptable daily intake of DDT compounds was established by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR-FAO/WHO) to 10 µg/kg body weight/day, based on developmental toxicity in rat offspring after maternal exposure (JMPR, 2001). Using a body weight of 76.6 kg, the estimated medium-bound per capita intake of p,p'-DDE from the 2015 market baskets ranged between 1.4 and 2.7 ng/kg body weight, which is more than 1000 times lower than the intake considered safe for consumers by JMPR. Even if a much lower body weight is used, as in the case of children, adolescents and young women, the per capita intake of p,p'-DDE is not of concern.

JECFA (2011) concluded that body burdens of DDT compounds below 1 µg/g lipid are safe from a human health perspective (developmental effects and cancer). In Sweden p,p'-DDE body burdens are, with few exceptions, generally below 1 µg/g lipid (Bjermo et al., 2013), also in pregnant women (Glynn et al., 2011; Lignell et al., 2015), which further strengthen the conclusion that the current average exposure to p,p'-DDE is of no health concern in Sweden.

WHO has proposed a health-based guidance value for HCB intake of 160 ng HCB/kg body weight/day, based on animal studies of cancer (IPCS, 1998). The per capita intake of HCB in the 2015 market basket was around 1 ng HCB/kg body weight/day when using a body weight of 76.6 kg. This is more than a 100-fold lower than the proposed guidance value. Even when lower body weight of children and adolescents are used the per capita intake per kilo body weight is considerable lower than the guidance value.

11.7.5 Conclusion

Of the chlorinated pesticides/metabolites included in the market basket study p,p'-DDE and HCB has been measured in all food group baskets in 1999-2015. Total per capita intake of both substances has declined during the study period, with a 3-fold faster decline for p,p'-DDE. Per capita intake for both substances is well below health-based guidance values for safe intake. For other pesticides/metabolites only fish baskets have been measured during the whole study period. For those substances with concentrations above LOQ during the study period per capita intake from fish has declined with around 4% per year, except for p,p'-DDT. No temporal trend could be detected for this major component of the DDT technical mixture. The increased per capita consumption of fish between 1999 and 2015 is a factor to consider in interpretation of the temporal trend results.

11.8 Brominated flame retardants (BFRs)

11.8.1 Background

Polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) have been used worldwide as flame retardants since the 1970s and have been added to a large variety of consumer products such as furniture upholstery, textiles, plastics and electronic products (Alaee et al., 2003). Strict bans have been imposed on the worldwide production and use of some PBDE formulations. Technical mixtures of penta- and octabromodiphenyl ether were banned globally in 2009 and since 2008 the use of decabromodiphenyl ether (BDE-209) has been banned in electronic applications within the EU (UNEP, 2009; Renner, 2004; European Court of Justice, 2008). Despite these bans, the release of PBDEs from existing products that are in service or have been disposed of in landfill sites is likely to continue for many years to come.

11.8.2 Chemical analysis

Polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD), a total of 11 analytes, were analysed in 30 samples from food groups mainly contributing to POP exposure. One sample per each food group and basket was analysed, see Table 11.8:1.

The analyses were performed in spring to autumm in 2016 at NFA. The analytical method used has been described elsewhere (Törnkvist et al., 2011). Small modifications of the method were made. Briefly, food homogenates were extracted with a mixture of hexane/acetone and hexane/diethyl ether. After evaporation of the organic solvents the lipid content was determined gravimetrically. The extracts were redissolved in hexane and the lipids were removed by sulfuric acid treatment. Further cleanup was done on a silica gel column. The analytes were eluted with a mixture of hexane and dichloromethane. BDE-85 and 13C-BDE-209 were used as internal standards. PBDEs (BDE-28, -47, -66, -99, -100, -138, -153, -154, -183 and -209) and HBCD were measured by gas chromatography/ mass spectrometry (GC/MS) in electron capture negative mode.

Analytical quality control
All glassware was heated or rinsed with acetone prior to use to minimize the risk of contamination, in particular contamination of BDE-209 via dust. Each batch of samples was analysed together with a laboratory blank and a quality control sample to verify the accuracy of the method and reported levels were corrected for levels found in the blank samples. The analytical method used is accredited for milk and not for composed food. Estimated LOQ were set to either six times the standard deviation of the blank value or to the lowest standard concentration, the highest of them two was chosen. The LOQ varied between 0.25 and 10 pg/g fresh weight, depending on the analyte, highest LOQ was determined for BDE-47, -99 and -209. LOQ for BDE-47, -99 and -209 have been revised after the latest market basket study, 2010, due to higher blank levels of BDE-47, -99 and -209.

11.8.3 Analytical results

BFR levels in the food groups analysed are very low, mostly below LOQ, see Table 11.8:1. BDE-138 and -183 are below LOQ in all the samples analysed. The food group with the highest actual sum BFR concentrations (not extrapolated) is fish (272 pg/g f.w.)

followed by fats (60 pg/g f.w.). BDE-209, HBCD and BDE-47 are the most common BFRs detected, with maximum concentrations of 51, 73 and 149 pg/g fresh weight, respectively.

Mean values presented in Table 11.8:1 are calculated as medium bound levels (results <LOQ are set to half the LOQ value), as lower bound (results < LOQ are set to zero) or as upper bound where results < LOQ are set to the LOQ value. Mean values calculated using non-extrapolated levels that are above the limit of detection (LOD) but below the limit of quantification (LOQ) are also reported as mean NE. As the majority of the results are <LOQ, the mean NE values are used in the statistical analysis of temporal trends of per capita BFR intake. The use of NE values are more appropriate in statistical analyses of temporal trends than lower-, medium- or upper-bound intake estimates. NE data below LOQ will result in less bias compared to replacement with ½LOQ which introduces a systematic error (RSC, 2001; Bergstrand and Karlsson, 2009).

Table 11.8:1 PBDE and HBCD levels in food homogenates of selected market basket food groups. Levels are given in pg/g fresh weight and mean values are presented as medium bound (MB), lower bound (LB), upper bound (UB) and as non-extrapolated mean (NE). Number (N) of samples analysed per each food group and number of results <LOQ are also reported.

Food group			**Concentration in pg/g fresh weight**					
		Fat %	**BDE-28**	**BDE-47**	**BDE-66**	**BDE-99**	**BDE-100**	**BDE-138**
Egg	Mean MB	10.9	1.25	5	1.3	5	1.25	1.25
N=5	Mean LB		0	0	0	0	0	0
	Mean UB		2.5	10	2.6	10	2.5	2.5
	Mean NE		0.01	0.972	0.002	2.01	0.806	0.066
	<LOQ/all		5/5	5/5	5/5	5/5	5/5	5/5
Fish	Mean MB	11.0	8.26	124	16.2	13.8	34.3	2.21
N=5	Mean LB		8.26	124	16.2	13.8	34.3	1.25
	Mean UB		8.26	124	16.2	13.8	34.3	3.17
	Mean NE		8.26	124	16.2	13.8	34.3	1.25
	<LOQ/all		0/5	0/5	0/5	0/5	0/5	4/5
Meat	Mean MB	12.6	1.2	5	1.2	5	1.2	1.2
N=5	Mean LB		0	0	0	0	0	0
	Mean UB		2.4	10	2.4	10	2.4	2.4
	Mean NE		0	1.88	0	2.07	0.456	0.104
	<LOQ/all		5/5	5/5	5/5	5/5	5/5	5/5
Diary prod. L	Mean MB	1.60	1.2	5	1.2	5	1.2	1.2
N=5	Mean LB		0	0	0	0	0	0
	Mean UB		2.5	10	2.5	10	2.5	2.5
	Mean NE		0.058	0.75	0.028	0.754	0.012	0.02
	<LOQ/all		5/5	5/5	5/5	5/5	5/5	5/5

Table 11.8:1 cont.

Food Group		Concentration in pg/g fresh weight						
		Fat %	**BDE-28**	**BDE-47**	**BDE-66**	**BDE-99**	**BDE-100**	**BDE-138**
Diary prod. S	Mean MB	25.5	1.25	9.52	1.25	6.78	1.59	1.25
N=5	Mean LB		0	6.52	0	2.78	0.59	0
	Mean UB		2.5	12.5	2.5	10.8	2.59	2.5
	Mean NE		0	9.44	0.05	6.30	1.45	0.036
	<LOQ/all		5/5	3/5	5/5	4/5	4/5	5/5
Fats, oils	Mean MB	67.9	1.25	5	1.25	10.9	1.25	1.25
N=5	Mean LB		0	0	0	9.86	0	0
	Mean UB		2.5	10	2.5	11.9	2.5	2.5
	Mean NE		0.258	5.11	0.856	11.8	1.96	0.266
	<LOQ/all		5/5	5/5	5/5	1/5	5/5	5/5

Table 11.8:1 cont.

Food group			Concentrations in pg/g fresh weight				
		Fat %	**BDE-153**	**BDE-154**	**BDE-183**	**BDE-209**	**HBCD**
Egg	Mean MB	10.9	1.25	1.25	1.65	7.5	4.06
N=5	Mean LB		0	0	0.65	3.5	2.06
	Mean UB		2.5	2.5	2.65	11.5	6.06
	Mean NE		0.620	0.842	1.01	10	2.59
	<LOQ/all		5/5	5/5	4/5	4/5	4/5
Fish	Mean MB	11.0	4.63	17.54	1.2	5	48.1
N=5	Mean LB		4.63	17.54	0	0	48.1
	Mean UB		4.63	17.54	2.4	10	48.1
	Mean NE		4.63	17.54	0.108	4.52	48.1
	<LOQ/all		0/5	0/5	5/5	5/5	0/5
Meat	Mean MB	12.6	1.2	1.2	1.63	6.5	3.37
N=5	Mean LB		0	0	0.66	2.5	1.37
	Mean UB		2.4	2.4	2.58	10.5	5.37
	Mean NE		1.2	0.83	1.39	5.87	3.20
	<LOQ/all		5/5	5/5	4/5	4/5	4/5
Diary prod. L	Mean MB	1.60	1.2	1.2	1.2	7.16	2.5
N=5	Mean LB		0	0	0	3.16	0
	Mean UB		2.5	2.5	2.5	11.2	5
	Mean NE		0.026	0.108	0.048	3.38	0
	<LOQ/all		5/5	5/5	5/5	4/5	5/5
Diary prod. S	Mean MB	25.5	1.62	1.25	1.25	5	2.5
N=5	Mean LB		0.62	0	0	0	0
	Mean UB		2.62	2.5	2.5	10	5
							5
	Mean NE		1.23	0.444	0.092	0.296	1.94
	<LOQ/all		4/5	5/5	5/5	5/5	5/5
Fats, oils	Mean MB	67.9	1.58	1.25	1.55	30.0	7.46
N=5	Mean LB		0.58	0	0.55	30.0	6.46
	Mean UB		2.58	2.5	2.55	30.0	8.46
	Mean NE		1.98	0	1.07	30.0	7.02
	<LOQ/all		4/5	5/5	4/5	0/5	2/5

Table 11.8:2. Total per capita intake of brominated flame retardants (median (range)). In cases when concentrations were below LOQ measured concentrations after blank substraction were used. Concentrations were set to zero in cases when blank-substracted concentrations were zero or negative.

Food group	BDE-28	BDE-47	BDE-66
Meat	0.00 (0.00-0.00)	0.00 (0.00-1.5)	0.00 (0.00-0.00)
Fish	0.40 (0.29-0.43)	5.5 (4.5-6.8)	0.78 (0.60-0.81)
Dairy prod., fluids	0.00 (0.00-0.29)	0.00 (0.00-1.1)	0.00 (0.00-0.05)
Dairy prod., solids	0.00 (0.00-0.00)	0.005 (0.003-0.02)	0.00 (0.00-0.0002)
Eggs	0.00 (0.00-0.001)	0.03 (0.002-0.05)	0.00 (0.00-0.0003)
Fats and oils	0.008 (0.00-0.03)	0.21 (0.17-0.36)	0.03 (0.01-0.09)
Sum	**0.42 (0.30-0.52)**	**6.3 (5.6-7.9)**	**0.85 (0.62-0.95)**
	BDE-99	**BDE-100**	**BDE-138**
Meat	0.00 (0.00-1.6)	0.00 (0.00-0.40)	0.00 (0.00-0.11)
Fish	0.66 (0.52-0.76)	1.7 (1.3-1.9)	0.00 (0.00-0.29)
Dairy prod., fluids	0.00 (0.00-1.2)	0.00 (0.00-0.02)	0.00 (0.00-0.03)
Dairy prod., solids	0.004 (0.0009-0.01)	0.01 (0.0006-0.02)	0.00 (0.00-0.00001)
Eggs	0.06 (0.04-0.08)	0.01 (0.008-0.05)	0.00 (0.00-0.006)
Fats and oils	0.50 (0.42-0.62)	0.08 (0.08-0.10)	0.03 (0.00-0.003)
Sum	**1.4 (1.1-2.8)**	**1.6 (1.5-2.2)**	**0.03 (0.00-0.29)**
	BDE-153	**BDE-154**	**BDE-183**
Meat	0.31 (0.14-3.6)	0.19 (0.0-0.28)	0.20 (0.14-0.70)
Fish	0.22 (0.19-0.24)	0.78 (0.65-1.0)	0.00 (0.00-0.02)
Dairy prod., fluids	0.00 (0.00-0.04)	0.01 (0.00-0.11)	0.00 (0.00-0.08)
Dairy prod., solids	0.0007 (0.00-0.02)	0.0004 (0.00-0.0006)	0.0002 (0.00-0.0002)
Eggs	0.02 (0.004-0.04)	0.01 (0.007-0.06)	0.01 (0.007-0.09)
Fats and oils	0.08 (0.06-0.13)	0.00 (0.00-0.00)	0.04 (0.02-0.12)
Sum	**0.63 (0.41-0.73)**	**1.1 (0.82-1.1)**	**0.23 (0.19-0.91)**
	BDE-209	**HBCD**	
Meat	1.4 (0.00-2.7)	0.66 (0.00-1.4)	
Fish	0.14 (0.08-0.51)	2.5 (0.70-3.4)	
Dairy prod., fluids	0.00 (0.00-5.1)	0.00 (0.00-0.00)	
Dairy prod., solids	0.00 (0.00-0.001)	0.001 (0.0006-0.004)	
Eggs	0.24 (0.17-0.48)	0.01 (0.00-0.29)	
Fats and oils	1.2 (0.75-2.3)	0.38 (0.06-0.56)	
Sum	**3.4 (1.2-8.0)**	**3.1 (1.1-5.3)**	

11.8.4 Exposure estimation, time trends

BFR concentrations were in many cases below LOQ. In case of concentrations below LOQ, the NE concentrations were used in the intake calculations. These measured concentrations are not extrapolated to half the LOQ or set to zero (see mean non-extrapolated concentrations in Table 11.8:1). In the previous Market Basket Study 2010, a comparison of NE per capita intakes with extrapolated medium-bound intakes (concentrations<LOQ = ½ LOQ) showed that the medium-bound intakes generally were higher than the NE per capita intakes, suggesting an over-estimation of per capita exposure intake when using the medium-bound approach (NFA, 2012). The use of NE data therefore most probably gives a more realistic estimate of the per capita intake of BFRs than the medium-bound approach, especially if there are many samples with concentrations below LOQ. Moreover, in analyses of temporal trends of per capita

intakes the use of NE data increases the statistical power to detect temporal trends, despite the fact that the NE data are more uncertain than data above LOQ. The use NE data below LOQ will result in less bias compared to replacement with ½LOQ which introduces a systematic error (RSC, 2001; Bergstrand and Karlsson, 2009). In the market basket studies from 1999 and 2005 per capita exposure estimates based on NE data were not available.

In 2015, BDE-47, BDE-209 and HBCD showed the highest median total per capita intakes, being above 3 ng/day (Table 11.8:2). Median per capita intakes of BDE-99, BDE-100 and BDE-154/ were all above 1 ng/day. There were substantial congener-specific differences in contribution of food groups to BFR intake, suggesting differences in contamination sources of foods (Table 11.8:3). The fish group gave the highest contribution to the total per capita intake of BDE-28, BDE-47, BDE-100 and BDE-154, generally more than 75% (Table 11.8:3). For BDE-99 and BDE-138 the fish and fat groups each contributed with 20-40% to the total intake. The meat group contributed to over 70% of BDE-183 intake, whereas the fat group contributed most to the BDE-209 intake (40%) (Table 11.8:3).

Table 11.8:3. Median contribution (range) of the different food groups to the total per capita exposure of brominated flame retardants

Compounds	Fish (%)	Meat (%)	Dairy pr. (%)	Eggs (%)	Fats, oils (%)
BDE-28	93 (82-100)	0 (0-0)	3.6 (0-18)	0.06 (0-0.24)	2.8 (0-6.6)
BDE-47	87 (71-94)	5.3 (0-19)	4.0 (0.04-18)	0.43 (0.02-0.86)	3.5 (2.9-5.0)
BDE-99	39 (18-53)	16 (0-56)	8.9 (0-56)	3.5 (1.2-5.3)	33 (15-46)
BDE-100	88 (77-94)	4.7 (0-18)	0.32 (0.04-1.3)	1.3 (0.47-3.6)	5.0 (4.0-5.4)
BDE 138	21 (0-100)	13 (0-64)	3.8 (0-19)	3.9 (0-18)	38 (0-94)
BDE-153	38 (30-48)	42 (27-55)	1.3 (0-6.1)	2.9 (1.0-5.9)	16 (9.1-21)
BDE-154	78 (64-93)	17 (0-25)	3.2 (0-10)	2.2 (0.91-5.5)	0 (0-0)
BDE-183	1.5 (0-4.4)	76 (68-87)	1.7 (0-8.5)	8.1 (1.6-22)	13 (5.2-20)
BDE-209	6.7 (1.4-16)	25 (0-63)	14 (0-64)	11 (3.0-21)	42 (14-72)
HBCD	65 (47-81)	22 (0-36)	0.09 (0.02-0.34)	1.9 (0-6.7)	10 (1.4-18)

Analyses of temporal trends of total per capita intake during the whole study period 1999-2015 was done using log-linear regression analysis. In 1999 intake was estimated for four major cities in Sweden (Malmö, Göteborg, Uppsala, Sundsvall, N=4), based on purchases from two food chains in each city. In 2005 per capita intake was estimated for the two food chains in each city separately (N=8). In 2010 two baskets were purchased (low and normal priced baskets) in each of four food chains sampled in Uppsala, and one basket (low price) from one Uppsala food chain (N=9). In 2015 normal-priced baskets were purchased from five retail chains in Uppsala 2015 (N=5) (Fig. 11.8:1). The studies 1999 and 2005 showed no systematic differences in per capita intakes of BFRs between food chains and between cities, supporting the hypothesis that there are no regional differences in contamination of the food supply in Sweden. Based on these results the study was performed in one city in 2010 and 2015 for logistic reasons. Total per capita intake of BDE-47 and BDE-99 decreased around 10% per year (Fig. 11.8:1). The results

show that the efforts to decrease emissions of lower brominated PBDEs have resulted in reduced contamination of foods. A decreased exposure to lower brominated PBDEs in Sweden is supported by the decreased concentrations of lower brominated BDEs in mother´s milk sampled in Sweden between 1996 and 2014 (Lignell et al., 2015).

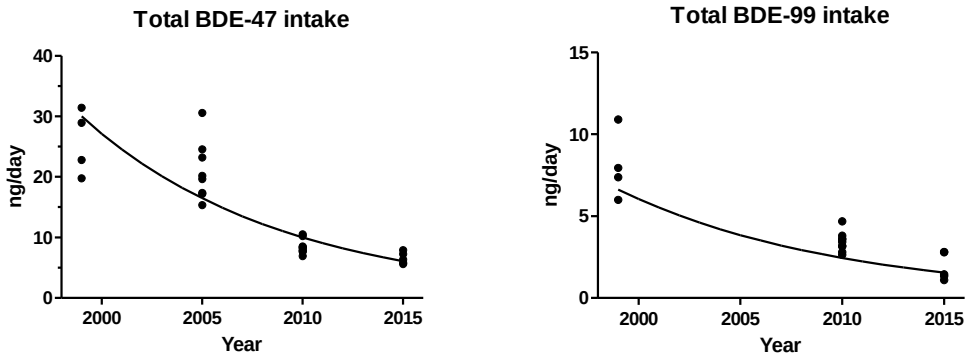


Figure 11.8:1. Temporal trends of total per capita intake of BDE-47 and BDE-99 in Sweden 1999-2015. Due to the log transformation of per capita intakes, the linear regression coefficient gives the % change of per capita intake per year. BDE-47 intake decreased 10% (mean; standard error: 0.97%; $p<0.001$) and BDE-99 intake decreased 9.0% (SE: 1.1%, $p<0.001$). Intake data of BDE-99 from 2005 is lacking since concentrations in many food groups were below LOQ and data on detectable concentrations below LOQ were not available.

BDE-209 was only analysed in market baskets from 2010 and 2015. The median total per capita intake was almost halved from 2010 to 2015, being marginally significant ($p=0.08$), suggesting decreased dietary exposure. Analyses of future market baskets are needed in order to draw firm conclusions about temporal trends of dietary BDE-209 exposure in Sweden. BDE-153 and HBCD have been analysed in market baskets since 2005, being mostly below LOQ in foods in the 2005 market baskets (except in fish). Using NE data from 2010 and 2015 a more than 3-fold decrease in median total per capita intake of HBCD was observed (Fig. 11.8:2), whereas the decline in BDE-153 intake was less pronounced (about 1.4-fold).

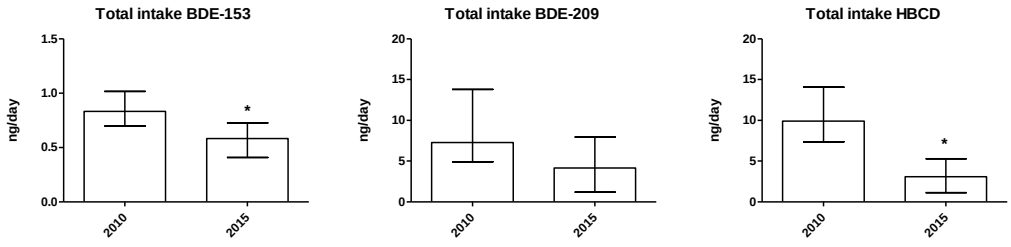


Figure 11.8:2. Total per capita intake (median, range) of BDE-153, BDE-209 and HBCD (ng/day) in 2010 and 2015. *Significantly different from intakes in 2010 (Mann-Whitney U test, N=5-9; $p\leq0.05$)

Temporal trends of BDE-47, BDE-99, BDE-100 and BDE-154 in fish could be assessed for the whole study period 1999-2015. For BDE-28, BDE-66 and HBCD trends between 2005 and 2015 could be analysed. Declining trends (3-10% per year) were observed for all flame retardants except BDE-28 (Table 11.8:4). Since the per capita fish consumption has not decreased during the study period, the results strongly suggest that BFR contamination of fish on the Swedish market has declined during the last decades.

Table 11.8:4. Temporal trends of per capita BFR intake from fish assessed by log-linear regression analysis. Due to the log transformation of BFR concentrations, the linear regression coefficient gives the % change of BFR intake per year

Compound	Period	N	% change	P for trend
BDE-28	2005-2015	22	-1.3±1.6	0.452
BDE-47	1999-2015	26	-7.2±0.89	<0.001
BDE-66	2005-2015	22	-6.4±2.9	0.041
BDE-99	1999-2015	26	-9.2±1.1	<0.001
BDE-100	1999-2015	26	-4.1±1.1	<0.001
BDE-154	1999-2015	26	-2.8±1.0	0.009
HBCD	2005-2015	22	-10±3.7	0.013

11.8.5 Risk assessment

In 2011 the CONTAM panel of EFSA assessed the human health risks with dietary intake of PBDEs and HBCD (EFSA, 2011c,d). The data base did not allow for determination of health-based tolerable intakes. Moreover, no assessment of health risks connected to the total intake of PBDEs could be done. However, the panel used benchmark modeling in order to determine the lower-bound 90th percentile (BMDL) intake of single PBDE congeners based on the BMDL body burden associated to a 10% increase in neurodevelopmental effects in mice. Using these BMDL intakes the panel concluded that the current margin of exposure (MOE) between the BMDL and the intake of BDE-47, -153 and -209 and HBCD from food within the EU does not raise health concerns. For BDE-99, however, the panel concluded that there is a potential health concern with respect to current dietary exposure. The CONTAM panel stated that in the case of PBDEs in principle any MOE larger than 2.5 indicates that there is unlikely to be a health concern. The larger the MOE is, the smaller is the potential health concern (EFSA, 2011c,d).

Table 11.8:5. Margin of exposure (MOE) between the median per capita intakes of PBDEs in 2015 and the lower-bound 90th percentile benchmark intake corresponding to a 10 % increase in neurodevelopmental effects (N=5)

Compound	Per capita intake[a] (ng/kg/d)	BMDL intake[b] (ng/kg/d)	MOE
BDE-47	0.07-0.10	172	1700-2500
BDE-99	0.01-0.04	4.2	110-300
BDE-153	0.005-0.01	9.6	1000-1800
BDE-209	0.03-0.10	1700000	>100000
HBCD	0.01-0.07	3000	>10000

[a]Body weight 76.6 kg
[b]EFSA (2011a,b) (BMDL=benchmark dose (lower confidence limit))

Based on the total per capita exposure estimated in the Swedish market basket study 2015, the margin of exposure (MOE) between the current average exposure of BDE-99 among adults in Sweden and BMDL intake are estimated to be 110-300 (Table 11.8:5). For BDE-47, BDE-153, BDE-209 and HBCD MOEs were considerably higher. MOEs for some of the BFRs are most probably lower in certain subgroups of the Swedish population, for instance groups with high consumption of fish. In the current study a body weight of 76.6 kg was used in the calculation of intake per kilo body weight. This body weight results in an underestimation of intakes per kilo body weight among children and young women. The BMDL intake in Table 11.8:5 is most relevant for life-time intake among women before pregnancy, since the most sensitive end-point in the EFSA risk assessment was neurodevelopmental effects after early life exposure (EFSA, 2011c,d). Nevertheless the large MOEs in Table 11.8:5 suggest that the per capita intake of the studied BFRs are well below a MOE estimated by EFSA to be of health concern (<2.5), even among young women with a lower body weight than 76.6 kg.

In the Market Basket 2010 an effort was made to assess the health risks associated with per capita intake of the total BFR mixture (NFA, 2012). It was concluded that the BFR mixture total per capita intake was unlikely to be a health concern. Since the per capita intake of the studied BFRs has not increased between 2010 and 2015 the conclusion from 2010 is still valid. The following procedure was used in 2012 to risk assess the BFR mixture per capita intake. Each flame retardant in the baskets was assigned a relative potency factor (Repf), describing the toxicity of the compound in relation to the most toxic BDE-99. The BMDL intakes estimated for neurotoxicity by EFSA were used in the assignment of Repfs, with the BMDL intake of BDE-99 as a reference point (Repf=1). Using this approach BDE-47 was assigned a Repf of 0.02, BDE-153 0.43, BDE-209 $2.5*10^{-6}$, and HBCD a Repf of 0.001. The PBDEs analysed by us that lacked BMDL data for neurotoxicity (BDE-28, -66, -100, -154 and -183) was in this conservative approach assigned a Repf of 1. The median total per capita intake of the single flame retardants were then multiplied by its respective Repf, and the resulting intakes were added together to a total BFR intake (0.09 ng/kg body weight/day). The MOE between this intake in Market Basket 2010 and the BMDL for the most toxic BDE-99 was 47, which is

considerably higher than the MOE of 2.5 proposed by EFSA as being unlikely to be a health concern (NFA, 2012).

11.8.6 Conclusion

The current per capita intakes of PBDEs and HBCDs in Sweden is most likely not a health concern, even if health risks with intake of the total mixture are taken into account. Per capita intakes have generally decreased except for BDE-209, which currently is the least regulated substance among the studied BFRs.

11.9 Phosphorous flame retardants (PFRs)

11.9.1 Background

Phosphorous flame retardants (PFRs) are gaining increased interest, because of the continouing demand for effectice flame retardant compounds and the phasing out of certain compounds (e.g. PBDEs and HBCD) due environmental and health problems and resulting restrictions. Although PFRs have already been used for several decades, and been found in various environmental compartments, data on environmental persistence and toxicity are still limited. Because of the known and suspected adverse health effects from PFRs, and their ubiquitous occurrence in environment and biota, this compound group may pose a threat to human health. However, information on the presence of PFRs in foodstuffs, and the exposure from food, is still scarce.

11.9.1 Chemical analysis

Food samples (ca 0.5 g of dry sample) from the market basket survey, representing 13 different food categories, were extracted and cleaned up as fully reported by Poma et al., (2017). Analyses were performed by GC-MS in the electron-ionization (EI) mode. Mean recoveries of internal standards ranged between 53 and 71%, except for tris(2-butoxyethyl) phosphate TBOEP-d6 (33%). LOQs were calculated as the “blank + 3*SD of the blank” and normalized by sample weight. Further general analytical issues on PFRs are discussed by Brandsma et al. (2013). The chemical analyses were carried out at the Toxicological Center of the University of Antwerp. Abbreviations of PFR substances (see Table 11.9:1) follow the nomenclature review by Bergman et al. (2012).

Table 11.9:1. Abbreviations of eight PFRs analysed in Market Basket 2015

Abbreviation	Complete name
TDCIPP	Tris(1,3-dichloro-2-propyl) phosphate
TCIPP	Tris(1-chloro-2-propyl) phosphate
TCEP	Tris(2-chloroethyl) phosphate
TNBP	Tri-n-butyl phosphate
TEHP	Tris(2-ethylhexyl) phosphate
TPHP	Triphenyl phosphate
TBOEP	Tris(2-butoxyethyl) phosphate
EHDPHP	2-Ethylhexyl diphenyl phosphate

The LOQs varied from 50 – 3000 pg/g fresh wt. (but were for fats considerably higher), depending on analyte and food group and the detection frequencies varied between 0% and 45% (Table 11.9:2).

11.9.2 Analytical results

The complete table of results is given in Annex VIII, and the results are also presented more in depth in the paper of Poma et al., 2017. The analytical results showed varying results as regards concentrations in comparison to the LOQ level and some of the analytes were constantly below LOQ. Thus, TNBP, TEHP and TBOEP, having 4, 0, and 0 % detection frequency, respectively (cf. Table 11.9:2), were not included in the subsequent data presentation. Concentration data for the other five PFRs in the market basket food groups are given in Table 11.9:3.

Table 11.9:2. Limits of quantification (LOQs) for the eight analysed PFRs, and percentage of analysed values above LOQs

PFR compound	LOQ (pg/g fresh wt.)	Detection frequency (%)
TDCIPP	50-500 (fats 2 000)	42
TCIPP	50-400 (fats 1 500)	30
TCEP	150-500 (fats 2 000)	17
TNBP*	300-3 000 (fats 8 000)	4
TEHP*	200-2 150 (fats 5 000)	0
TPHP	50-500 (fats, 6 000)	32
TBOEP*	300-3 000 (fats 6 000)	0
EHDPHP	200-3 000 (fats 6 000)	45

*Not considered in further calculations due to low detection frequency

Generally, the EHDPHP levels were the highest among the analysed PFRs, and with the highest detection frequency (45%). Among the analysed food categories, cereals, pastries, fats/oils and sugar/sweets were characterized by the highest EHDPHP levels. The second highest detection frequency was registered for TDCIPP, and in this case, the major contributing food categories (most data above LOQ) were the food categories vegetables, fruit, potatoes and beverages.

Table 11.9:3. Levels of PFRs in the 2015 market basket food categories, purchased on the Swedish market (pg/g fresh wt; mean/median (MB) of 2-5 analyses and range)

Sample cat.		TCEP	TPHP	EHDPHP	TDCIPP	TCIPP sum 1+2
Cereal prod.	mean	250	335	4171	379	1232
	median	250	250	4236	250	589
	range	all <500	<500-673	<3000-9248	<500-893	<400-2803
Pastries	mean	250	745	9250	250	807
	median	250	745	9250	250	807
	range	all <500	<500-1240	8443-10057	all <500	701-914
Meat	mean	100	458	643	184	75
	median	100	228	500	100	75
	range	all <200	<200-1539	<1000-1215	<200-522	all <150
Fish	mean	100	629	2462	290	75
	median	100	434	1753	100	75
	range	all <200	<200-1561	<1000-5802	<200-1051	all <150
Dairy prod.,	mean	127	75	425	175	63
fluids	median	121	75	425	75	63
	range	<100-218	<100-<200	<700-<1000	<100-500	<100-<150
Dairy prod.,	mean	150	150	1000	150	100
Solids	median	150	150	1000	150	100
	range	all <300	all <300	all <2000	all <300	all <200
Eggs	mean	81	81	906	179	133
	median	75	75	888	124	114
	range	<150-<200	<150-<200	584-1263	<150-393	<150-231
Fats, oils	mean	1000	4742	5080	1000	750
	median	1000	2621	4853	1000	750
	range	all <2000	1356-12370	<6000-7613	all <2000	all <1500
Vegetables	mean	414	67	282	366	182
	median	445	58	288	211	167
	range	315-506	<50-131	<200-394	<50-1061	<50-333
Fruit	mean	92	75	469	292	108
	median	75	75	350	237	75
	range	<150-161	all <150	<700-946	<150-574	<150-241
Potatoes	mean	111	183	350	290	167
	median	75	75	350	290	176
	range	<150-255	<150-476	all <700	177-485	<150-278
Sugar and	mean	225	250	3711	739	200
sweets	median	225	250	3711	739	200
	range	all <450	all <500	<3000-5923	<500-1228	all <400
Beverages	mean	225	250	1500	855	200

	median	225	250	1500	855	200
	range	all <450	all <500	all <3000	642-1069	all <400

11.9.3 Exposure estimation

The estimated per capita intakes of the five considered PFRs have been calculated in Table 11.9:4 (based on MB values). When the consumption figures are included, they generally give the largest weight to cereals, pastries, fats/oils, sugar/sweets, and beverages, but compound differences occur. The largest intake comes from EHDPHP, adding up to 3.3 µg/person and day, or 49 ng/kg bw/day, followed by TDCIPP at 12 ng/kg bw/day. For EHDPHP, the four most prominent food categories (cereals, pastries, sugars, and beverages) constituted 71% of the total mean intake, while the corresponding figure for TDCIPP was 57%.The relative contribution from these four food categories to the total intake differed however widely between the two compounds.

Table 11.9:4. Estimated per capita intake of PFRs from the analysed food categories and summarized as the total PRF intake, based on medium bound levels, given in ng/person/day or (bottom line) ng/kg b.w./day (per capita body weight 76.6 kg).

Sample cat.	TCEP	TPHP	EHDPHP	TDCIPP	TCPP 1+2	Sum5	Sum5 (%)
Cereal prod.	57	77	955	87	282	1458	25.6
Pastries	12	36	448	12	39	547	9.6
Meat	21	97	136	39	15	308	5.4
Fish	4	28	112	13	3	160	2.8
Dairy pr., fluids	41	24	137	56	20	278	4.9
Dairy pr., solids	11	11	79	11	7	119	2.1
Eggs	2	2	25	4	3	36	0.6
Fats, oils	44	213	228	44	33	562	9.9
Vegetables	81	13	55	72	36	257	4.5
Fruit	21	17	109	67	25	239	4.2
Potatoes	14	23	44	36	21	138	2.4
Sugar, sweets	28	31	466	92	25	642	11.3
Beverages	70	78	472	269	63	952	16.7
TOTAL (ng/day)	406	650	3266	802	572	5696	100
TOTAL (ng/kg bw/day)	5,3	8.5	43	10	7,5	74	

To get some information on how levels below LOQ influenced the intake estimations, the intake calculations including all food categories have been performed on LB, MB, and UB basis (not shown). In this case, the ratio UB/LB, which indicate the influence of <LOQ levels, resulted in a factor above 5 for TCEP and thereby decreases the analysis

accuracy. TCEP is indeed the least detected compound (83% below LOQ). For the other compounds, the UB/LB factors are smaller (1.5-2.1).

The presented data on the estimated intake of PFRs *via* food should be considered valuable, as few earlier food intake studies have been presented. In a Swedish study, based on a fish consumption of 375 g/week and levels of the sum of eight PFRs in eelpout or in a general fish mix, the resulting consumption of ∑PFRs was calculated as 180, or 20 ng/kg bw/day (Sundkvist et al., 2010).

We found that some PFRs are present in levels above LOQ in many of the analysed food categories, and PFRs are not distributed in food similarly to lipophilic POPs, such as PCBs and chloropesticides, which are present at highest levels in foods of animal origin (e.g. Kiviranta e al., 2001; Freijer et al., 2001). A possible explanation could be the moderate lipophilicity of PFRs, which makes them less prone to accumulate in fat depots of food-producing animals compared to PBDEs (e.g. Malarvannan et al., 2015). Also, the lower accumulation of PFRs could be related to a relatively fast metabolism and excretion (Su et al., 2014; Greaves et al., 2016). The food categories with the highest levels (cereals, pastries, fats/oils, sugar etc.) are also industrially processed to a higher degree compared to many other food categories, and contamination during food processing is therefore a possibility. In addition, the presence of PFRs as plasticizers in food packages (which is the case for e.g. EHDPHP) may also play a role. As compounds within the PFR group have many different applications both as flame retardants and plasticizers, the release of compounds to the environments could take place as result from these various fields of application.

Time trends could not be followed due to lack of data.

11.9.4 Risk assessment

The paper of Ali et al. (2012) reported reference doses for several PFRs, which were obtained by dividing chronic NOAELs by a factor of 1,000. These reference doses were subsequently used in risk estimations by Malarvannan et al. (2015). For four of the analyzed PFR compounds in our study (i.e. TCEP, TPHP, TDCIPP and TCIPP), we could compare the calculated *per capita* intake with the reference doses given in the paper of Ali. Our calculated *per capita* intake figures of these four compounds (6-12 ng/kg bw/day; MB) were much lower than the corresponding reference doses (15 000-80 000 ng/kg bw/day), i.e. by a factor of more than 2 000. Consequently, our data show that there is a large margin between the estimated per capita intakes and corresponding reference doses. However, the present *per capita* intake estimates exposure from food only, and cannot be used to speculate what the total exposure to these compounds would be, as we did not study the other exposure routes in the present study. Also, as new studies emerge on biological effects of PFRs, this can have an effect on future NOAEL settings.

11.9.5 Conclusion

In conclusion, we have analysed eight PFRs in market basket samples obtained from Swedish shops in 2015. Measurable levels of PFRs were found in the majority of the 13 studied food groups and the highest PFR levels were generally found in samples from cereals, pastries, fats/oils, and sugar/sweets. The medium bound *per capita* intakes were estimated for five PFRs, ranging from 6 to 49 ng/kg bw/day (EHDPHP highest). In comparison to health-based reference doses, the estimated intake figures were lower by a factor of more than 2 000.

Although there is a large margin between the estimated food intakes and levels causing effects in animals, we still do not know enough about the total exposure to PFRs and its relation to health. However, at least for certain PFRs the intake from food can be equal or higher than dust inhalation and ingestion (Poma et al., 2017).

11.10 Poly- and perfluorinated alkyl substances (PFASs)

11.10.1 Background

Poly- and perfluorinated alkyl substances (PFASs) is a group of over 3000 chemicals that have many uses in society. They are surface active and fat/oil/water repellent and are used for treatment of textiles and paper, and in products such as lubricants, paints and fire-fighting foams. PFASs are very persistent in the environment and some homologues bioaccumulate in humans (Cousins et al., 2016). Knowledge about human exposure is still limited, but it has been shown that both food and drinking water are major sources of human exposure to some PFASs.

11.10.2 Chemical analysis

Overview

This method is suitable for the analysis of a suite of perfluoroalkyl acids and selected precursors in various food matrices. Target compounds and corresponding internal standard used in this market basket study are listed in Table 11.10:1.

Table 11.10:1. All internal standards were supplied by Wellington.

Target Compounds	Acronym[1]	Internal standard
Perfluorobutane sulfonic acid	PFBS	18O2-PFHxS
Perfluorohexane sulfonic acid	PFHxS	18O2-PFHxS
Perfluorooctane sulfonic acid	PFOS	13C4-PFOS
Perfluorodecane sulfonic acid	PFDS	13C4-PFOS
Perfluorooctane sulfonamide	FOSA	13C8-FOSA
Perfluorobutanoic acid	PFBA	13C4-PFBA
Perfluoropentanoic acid	PFPeA	13C5-PFPeA
Perfluorohexanoic acid	PFHxA	13C2-PFHxA
Perfluoroheptanoic acid	PFHpA	13C4-PFHpA
Perfluorooctanoic acid	PFOA	13C4-PFOA
Perfluorononanoic acid	PFNA	13C5-PFNA
Perfluorodecanoic acid	PFDA	13C2-PFDA
Perfluoroundecanoic acid	PFUnDA	13C2-PFUnDA
Perfluorododecanoic acid	PFDoDA	13C2-PFDoDA
Perfluorotridecanoic acid	PFTrDA	13C2-PFDoDA
Perfluorotetradecanoic acid	PFTeDA	13C2-PFDoDA
Perfluoropentadecanoic acid	PFPeDA	13C2-PFDoDA
Recovery Standards		
13C8 labeled Perfluorooctanoic acid	M8-PFOA	
13C8 labeled Perfluorooctane sulfonic acid	M8-PFOS	

[1] Acronyms are according to (Buck et al., 2011).

Sample preparation

A portion of homogenized sample (see Table 11.10:2 for sample size for each food group) was weighed into a 13 mL polypropylene tube and spiked with 50 µL of a 10 pg/µL internal standard solution. Four mL of acetonitrile along with 8-10 stainless steel beads (4.8 mm) were added, and the samples were homogenized using a bead blender (SPEX SamplePrep 1600 MiniG ®) for 4 minutes at 1500 rpm. The organic phase was transferred to a new 13 mL polypropylene tube and the extraction was repeated twice (total of 3 extractions). The combined extracts were concentrated to ~1 mL under a stream of nitrogen, then fortified with 9 mL water. WAX SPE cartridges (150 mg, 6 mL, Waters) were conditioned with 6 mL 2% ammonium hydroxide solution in methanol, 6 mL methanol, and 6 mL water. The sample extracts were then loaded onto the cartridges and washed with 1 mL 1% formic acid and 2 mL water, then dried under vacuum for ~5 minutes. Analytes were eluted with 4 mL 1% ammonium hydroxide solution in methanol into a 13 mL polypropylene tube. After evaporating to dryness under a stream of nitrogen the extracts were reconstituted in 150 µL methanol. The tubes were vortexed and the extract was filtered using centrifuge filters (modified nylon 0.2 µm, 500 µL, VWR International). Extracts were transferred to auto sampler vials and 50 µL recovery standard (10 pg/µL) was added prior to UPLC-MS/MS analysis.

Table 11.10:2. Sample amounts (wet weight)

Matrix	Amount (g)
Cereal products	1.0
Pastries	1.5
Eggs	1.5
Meat	1.5
Diary products	3.5
Fish	1.5
Fats and oils	1.5
Potatoes	3.5
Fruits	3.5
Vegetables	3.5
Sugar and sweets	1.5
Beverages	2.0

Instrumental analysis and quantification

An Acquity UPLC system (Waters) equipped with a BEH C18 (50 × 2.1 mm, 1.7 µm particle size, Waters) analytical column was used for all instrumental analyses. Mobile phase A was composed of 95% water and 5% methanol, while mobile phase B was composed of 75% methanol, 20% acetonitrile, and 5% water; both contained 2 mM ammonium acetate and 5 mM 1-methyl piperidine. Table 11.10:3 shows the mobile phases, gradient programs, and flow rates for the corresponding groups of compounds analyzed. The injection volume was 5 µL and the column temperature was set to 40°C. The UPLC system was coupled to a Xevo TQ-S triple quadrupole mass spectrometer (Waters), which was operated in negative ion electrospray ionization (ESI-) mode. The source and desolvation temperatures were set to 150°C and 350°C, respectively, and the

desolvation and cone gas flows were set to 650 L/h and 150 L/h, respectively. The capillary voltage was set to 3.0 kV. Optimized cone-voltages and collision energies for each compound are provided in Table 11.10:4.

Table 11.10:3. Mobile phase gradient program.

Time	Mobile phase A (%)[1]	Mobile phase B (%)[2]
0.0	90	10
0.5	90	10
5.0	20	80
5.1	0	100
8.0	0	100
10.0	90	10

Note: Flow rate was 0.4 mL/min, column temperature was 40 °C, and injection volume was 5 µL.
[1] Mobile phase A: 95 % water and 5 % methanol containing 2 mM ammonium acetate and 5 mM 1-methyl piperidine (1-MP).
[2] Mobile phase B: 75 % methanol, 20 % acetonitrile, and 5 % water containing 2 mM ammonium acetate and 5 mM 1-methyl piperidine (1-MP).

Table 11.10:4. Target compounds and selected instrumental parameters for quantification of each compound by UPLC/ESI-MS/MS.

Compound[1]	Precursors > product ion (qualitative product ion)	Cone voltage (V)	Collision energy (eV)	Internal standard[3]
PFBS	299 > 80 (99)	45	30	$^{13}C_2$-PFHxA
PFHxS	399 > 80 (99)	55	36	$^{18}O_2$-PFHxS
br-PFOS	499 > 99 (80)	65	40	$^{13}C_4$-PFOS
l-PFOS	499 > 99 (80)	65	40	$^{13}C_4$-PFOS
PFDS	599 > 80 (99)	80	46	$^{13}C_2$-PFUnDA
FOSA	498 > 78 (478)	8	28	$^{13}C_8$-FOSA
PFBA	213 > 169 (149)	20	10	$^{13}C_4$-PFBA
PFPeA	263 > 219 (169)	20	10	$^{13}C_4$-PFBA
PFHxA	313 > 269 (119)	20	10	$^{13}C_2$-PFHxA
PFHpA	363 > 319 (169)	21	11	$^{13}C_4$-PFHpA
PFOA	413 > 369 (169)	22	11	$^{13}C_4$-PFOA
PFNA	463 > 419 (219)	24	11	$^{13}C_5$-PFNA
PFDA	513 > 469 (269)	26	11	$^{13}C_2$-PFDA
PFUnDA	563 > 519 (269)	28	11	$^{13}C_2$-PFUnDA
PFDoDA	613 > 569 (169)	30	12	$^{13}C_2$-PFDoDA
PFTrDA	663 > 619 (169)	32	12	$^{13}C_2$-PFDoDA
PFTeDA	713 > 669 (169)	35	12	$^{13}C_2$-PFDoDA
$^{13}C_8$-PFOA[4]	421 > 376	22	11	
$^{13}C_8$-PFOS[4]	507 > 80	65	42	

[1] Acronyms are according to (Buck et al., 2011).
[2] Product ions in brackets were used as confirmation ions.
[3] All internal standards were purchased at Wellington Laboratories.
[4] $^{13}C_8$-PFOA and $^{13}C_8$-PFOS were used as recovery internal standards.

Quality control

Accuracy and precision were evaluated by analyzing spiked portions of each matrix (single sample or homogenized pool; Table 11.10:5) in triplicate. The native spiking concentration was approximately 10 times the IS concentration. Two procedural blanks were analyzed alongside the samples in each batch. Overall, internal standard-corrected percent recoveries were reasonable (usually between 80-120%) in cases where an exact-matched isotopically labelled internal standard was available (Table 11.10:6 and 11.10:7). In cases where a structurally-similar internal standard was employed, precision remained reasonable (<20% CV), but accuracy was sub-optimal. This was in particular the case for PFTrDA and PFTeDA in egg and cereal matrices, and PFDS in meat, fish, pastry, dairy, vegetables and potato matrices. These results should be considered qualitative and be interpreted cautiously. LODs were estimated based on the concentration producing a signal-to-noise ratio of 3, estimated using the lowest calibration standard.

Table 11.10:5. Sample amount, quality control samples (wet weight)

Matrix	Amount (g)	Sample ID (SLV)	Spiking Concentration (ng/g)
Cereal products	1.0	2	4.93
Pastries	1.5	20	3.31
Eggs	1.5	91	3.39
Meat	1.5	37	3.47
Diary products	3.5	Pooled	1.43
Fish	1.5	112	3.40
Fats and oils	1.5	62	3.69
Potatoes	3.5	Pooled	1.45
Fruits	3.5	Pooled	1.45
Vegetables	3.5	Pooled	1.44
Sugar and sweets	1.5	195	3.48
Beverages	2.0	Pooled	2.40

Table 11.10:6. Results of spike/recovery experiments (n=3/matrix). Values in parentheses are %CV. Recoveries less than 50% or greater than 150% are denoted by ***bold italics***.

	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA
Meat	90 (1)	76 (2)	92 (5)	85 (4)	87 (7)	89 (21)
Fish	73 (16)	74 (16)	68 (16)	79 (12)	82 (11)	80 (13)
Eggs	85 (1)	74 (6)	88 (5)	81 (3)	84 (3)	76 (8)
Cereal prod.	99 (4)	93 (9)	109 (8)	102 (9)	99 (3)	104 (6)
Pastries	106 (18)	88 (16)	110 (16)	100 (10)	102 (12)	106 (12)
Sugar, sweets	***204*** (4)	84 (15)	107 (9)	100 (14)	107 (8)	104 (10)
Dairy prod.[1]	86 (1)	91 (9)	105 (2)	98 (7)	98 (11)	97 (0)
Fats, oils	84 (5)	88 (10)	103 (10)	93 (9)	95 (2)	92 (6)
Beverages[1]	73 (2)	143 (12)	148 (2)	124 (3)	139 (7)	145 (5)
Vegetables[1]	103 (3)	85 (10)	96 (13)	90 (6)	91 (9)	90 (28)
Fruits[1]	96 (61)	NR	112 (10)	94 (1)	103 (5)	99 (4)
Potatoes[1]	86 (58)	94 (58)	103 (11)	95 (6)	90 (7)	118 (28)

	PFDA	**PFUnDA**	**PFDoDA**	**PFTrDA**	**PFTeDA**
Meat	98 (7)	104 (6)	105 (20)	84 (32)	71 (19)
Fish	93 (16)	97 (3)	99 (23)	87 (21)	131 (27)
Eggs	94 (5)	98 (5)	96 (4)	***36*** (7)	***22*** (11)
Cereal prod.	112 (5)	114 (8)	114 (4)	***47*** (8)	***38*** (7)
Pastries	109 (11)	117 (12)	120 (11)	60 (15)	***42*** (12)
Sugar, sweets	113 (10)	120 (11)	115 (12)	63 (6)	***41*** (8)
Dairy prod.[1]	118 (2)	135 (2)	114 (2)	115 (20)	107 (4)
Fats, oils	103 (6)	111 (7)	113 (8)	63 (16)	***27*** (39)
Beverages[1]	***153*** (9)	***163*** (10)	157 (5)	149 (5)	120 (7)
Vegetables[1]	99 (11)	103 (0)	101 (3)	***158*** (4)	101 (6)
Fruits[1]	104 (6)	109 (6)	105 (15)	121 (9)	72 (2)
Potatoes[1]	118 (2)	113 (4)	97 (25)	120 (18)	119 (24)

[1]n= 2 replicates

NR = Not reported due to analytical problems.

Table 11.10:7. Results of spike/recovery experiments (n=3/matrix). Values in parentheses are %CV. Recoveries less than 50% or greater than 150% are denoted by ***bold italics***.

	PFBS	L-PFHxS	L-PFOS	PFDS	PFOSA
Meat	74 (6)	89 (4)	83 (13)	***256*** (22)	72 (11)
Fish	68 (11)	81 (14)	80 (19)	***637*** (14)	76 (9)
Eggs	76 (4)	90 (7)	104 (7)	83 (6)	93 (4)
Cereal pr.	94 (15)	108 (14)	95 (2)	136 (9)	90 (7)
Pastries	70 (11)	84 (14)	82 (19)	***656*** (14)	83 (8)
Sugar, sweets	74 (4)	62 (7)	57 (6)	64 (4)	57 (18)
Dairy pr.[1]	89 (5)	102 (8)	108 (29)	***491*** (16)	7 (12)
Fats, oils	79 (6)	99 (11)	90 (9)	143 (14)	72 (9)
Beverages[1]	66 (3)	87 (1)	81 (7)	89 (2)	55 (7)
Vegetables[1]	56 (7)	94 (4)	87 (2)	***191*** (3)	81 (20)
Fruits[1]	53 (13)	98 (7)	90 (2)	149 (12)	89 (2)
Potatoes[1]	***45*** (4)	90 (4)	84 (11)	***318*** (1)	55 (22)

[1]n= 2 replicates

11.10.3 Analytical results

Many of the samples in the 2015 MB study had concentrations of perfluorinated sulfonic acids (PFSAs) and perfluorooctane sulfonamides below LOQ (Table 11.10:8). However, among the fish samples more than half had concentrations of linear and branched PFOS and linear PFOSA above LOQ. Linear PFHxS was above LOQ in 1 dairy sample, linear PFOS in 3 meat samples and in 2 egg samples, branched PFOS in 1 egg sample, linear PFOSA in 2 cereal samples and in 1 pastry and sugar/sweets sample, and branched PFOSA in 1 fish sample. The fish samples had linear PFOS and PFOSA concentrations above 100 ng/kg.

Among perfluorinated carboxylic acids (PFCAs) PFHxA and linear PFOA showed the largest number of samples with concentrations above LOQ (Table 11.10:9). For PFHxA, measurable concentrations were found in 2 egg samples, 4 fats/oils samples, 4 vegetable sampels, 1 fruit sample and 1 cereal sample. For PFOA, measurable concentrations were observed in meat (4), fish (4), egg (2), fats/oils (4), vegetable (4), fruit (1), and cereal (1) samples. The fish samples contained the largest number of measurable PFCAs, apart from PFOA also including PFNA (5 samples), PFDA (5), PFUnDA (5), PFDoDA (1), and PFTrDA (3). Concentrations of PFHxA and linear PFOA above LOQ were generally higher than 10 ng/kg, but below 50 ng/kg. In the fish samples, highest concentrations were observed for PFUnDA with a median concentration above 100 ng/kg.

Table 11.10:8. Mean, median (min-max) concentrations of PFSAs in market basket samples from 2015 (ng/kg). In calculation of means concentrations below LOQ were set to ½ of LOQ. Food groups having at least one basket with concentrations >LOQ in **bold**.

S	PFBS	l-PFHxS	br-PFHxS	l-PFOS	br-PFOS
Cereal prod.	3.5	1.5	1.5	4.0	4.0
	<7.0 (<7.0)	<3.0 (<3.0)	<3.0 (<3.0)	<8.0 (<8.0)	<8.0 (<8.0)
Pastries	3.5	1.5	1.5	4.0	4.0
	<7.0 (<7.0)	<3.0 (<3.0)	<3.0 (<3.0)	<8.0 (<8.0)	<8.0 (<8.0)
Meat	4.0	6.0	6.0	**15**	5.0
	<8.0 (<8.0)	<12 (<12)	<12 (<12)	**11 (<10-29)**	<10 (<10)
Fish	4.0	6.0	6.0	**228**	**18**
	<8.0 (<8.0)	<12 (<12)	<12 (<12)	**223 (134-303)**	**17 (<10-38)**
Dairy prod.	4.5	**6.0**	6.0	6.0	6.0
	<9.0 (<9.0)	**<10 (<10-10)**	<12 (<12)	<12 (<12)	<12 (<12)
Eggs	4.0	6.0	6.0	**33**	**6.2**
	<8.0 (<8.0)	<12 (<12)	<12 (<12)	**<10 (<10-128)**	**<10 (<10-11)**
Fats, oils	4.5	5.0	6.0	6.0	6.0
	<9.0 (<9.0)	<10 (<10)	<12 (<12)	<12 (<12)	<12 (<12)
Vegetables	2.5	3.5	3.5	2.0	2.0
	<5.0 (<5.0)	<7.0 (<7.0)	<7.0 (<7.0)	<4.0 (<4.0)	<4.0 (<4.0)
Fruits	2.5	3.5	3.5	2.0	2.0
	<5.0 (<5.0)	<7.0 (<7.0)	<7.0 (<7.0)	<4.0 (<4.0)	<4.0 (<4.0)
Potatoes	2.5	3.5	3.5	2.0	2.0
	<5.0 (<5.0)	<7.0 (<7.0)	<7.0 (<7.0)	<4.0 (<4.0)	<4.0 (<4.0)
Sugar sweets	3.5	1.5	1.5	4.0	4.0
	<7.0 (<7.0)	<3.0 (<3.0)	<3.0 (<3.0)	<8.0 (<8.0)	<8.0 (<8.0)
Beverages	4.5	5.0	6.0	6.0	6.0
	<9.0 (<9.0)	<10 (<10)	<12 (<12)	<12 (<12)	<12 (<12)
N<LOQ (%)	60 (100)	59 (98)	60 (100)	50 (83)	55 (92)

	PFDS	l-PFOSA	br-PFOSA
Cereal prod.	4.0	**14**	1.0
	<8.0 (<8.0)	**<2.0 (<2.0-38)**	<2.0 (<2.0)
Pastries	4.0	1.0	1.0
	<8.0 (<8.0)	<2.0 (<2.0)	<2.0 (<2.0)
Meat	7.0	0.50	0.50
	14 (<14)	<1 (<1.0)	<1 (<1.0)
Fish	7.0	**197**	**4.4**
	<14 (<14)	**472 (<1.0-611)**	**<1.0 (<1.0-20)**
Dairy	5.0	5.5	5.5
	<10 (<10)	<11 (<11)	<11 (<11)
Eggs	7.0	0.50	0.50
	<14 (<14)	<1 (<1.0)	<1 (<1.0)
Fats, oils	5.0	5.5	5.5
	<10 (<10)	<11 (<11)	<11 (<11)
Vegetables	0.50	3.5	3.5
	<1.0 (<1.0)	<7.0 (<7.0)	<7.0 (<7.0)
Fruits	0.50	3.5	3.5
	<1.0 (<1.0)	<7.0 (<7.0)	<7.0 (<7.0)
Potatoes	0.50	3.5	3.5
	<1.0 (<1.0)	<7.0 (<7.0)	<7.0 (<7.0)
Sugar sweets	4.0	**14**	1.0
	<8.0	**<2.0 (<2.0-38)**	<2.0 (<2.0)

	(<8.0)		
Beverages	5.0	5.5	5.5
	<10 (<10)	<11 (<11)	<11 (<11)
N<LOQ (%)	60 (100)	55 (92)	59 (98)

Table 11.10:9. Mean, median (min-max) concentrations of PFCAs in market basket samples from 2015 (ng/kg). In calculation of means concentrations below LOQ were set to ½ of LOQ. Food groups having at least one basket with concentrations >LOQ in **bold**.

Sample	**PFBA**	**PFPeA**	**PFHxA**	**PFHpA**	**l-PFOA**	**br-PFOA**
Cereal pr.	16	14	**11**	5.5	**25**	6.0
	<31 (<31)	<28 (<28)	**<12 (<12-33)**	<11 (<11)	**26 (20-32)**	<12 (<12)
Pastries	16	14	6.0	5.5	**12**	6.0
	<31 (<31)	<28 (<28)	<12 (<12)	<11 (<11)	**<12 (<12-18)**	<12 (<12)
Meat	16	17	5.0	5.0	**13**	6.0
	<32 (<32)	<33 (<33)	<10 (<10)	<10 (<10)	**15 (<12-16)**	<12 (<12)
Fish	16	17	5.0	5.0	**14**	6.0
	<32 (<32)	<33 (<33)	<10 (<10)	<10 (<10)	**15 (<12-19)**	<12 (<12)
Dairy pr.	16	18	4.5	6.0	7.0	7.0
	<31 (<31)	<35 (<35)	<9.0 (<9.0)	<12 (<12)	<14 (<14)	<14 (<14)
Eggs	16	17	**7.4**	5.0	**11**	6.0
	<32 (<32)	<33 (<33)	**<10 (<10-13)**	<10 (<10)	**<12 (<12-21)**	<12 (<12)
Fats, oils	16	18	**10**	6.0	**8.4**	7.0
	<31 (<31)	<35 (<35)	**10 (<9.0-14)**	<12 (<12)	**< 14 (<14-14)**	<14 (<14)
Vegetables	8.0	3.5	**15**	3.0	3.5	3.5
	<16 (<16)	<7.0 (<7.0)	**17 (<7-23)**	<6.0 (<6.0)	<7.0 (<7.0)	<7.0 (<7.0)
Fruits	8.0	3.5	**4.7**	3.0	3.5	3.5
	<16 (<16)	<7.0 (<7.0)	**<7.0 (<7.0-9.8)**	<6.0 (<6.0)	<7.0 (<7.0)	<7.0 (<7.0)
Potatoes	8.0	3.5	3.5	3.0	3.5	3.5
	<16 (<16)	<7.0 (<7.0)	<7.0 (<7.0)	<6.0 (<6.0)	<7.0 (<7.0)	<7.0 (<7.0)
Sugar sweets	16	14	6.0	5.5	**15**	6.0
	<31 (<31)	<28 (<28)	<12 (<12)	<11 (<11)	**15 (13-17)**	<12 (<12)
Beverages	16	18	4.5	6.0	7.0	7.0
	<31 (<31)	<35 (<35)	<9.0 (<9.0)	<12 (<12)	<14 (<14)	<14 (<14)
N<LOQ (%)	60 (100)	60 (100)	48 (60)	60 (100)	35 (58)	60 (100)
	PFNA	**PFDA**	**PFUnDA**	**PFDoDA**	**PFTrDA**	**PFTeDA**
Cereal pr.	5.5	6.0	5.5	5.5	6.0	5.0
	<11 (<11)	<12 (<12)	<11 (<11)	<11 (<11)	<12 (<12)	<10 (<10)
Pastries	5.5	6.0	5.5	5.5	6.0	5.0
	<11 (<11)	<12 (<12)	<11 (<11)	<11 (<11)	<12 (<12)	<10 (<10)
Meat	7.0	7.5	8.0	7.0	8.0	9
	<14 (<14)	<15 (<15)	<16 (<16)	<14 (<14)	<16 (<16)	<18 (<18)
Fish	**33**	**45**	**120**	**17**	**30**	9
	35 (24-41)	**41 (33-64)**	**122 (62-165)**	**<14 (<14-57)**	**22 (<16-56)**	<18 (<18)
Dairy pr.	5.0	**7.5**	7.0	6.0	6.5	7.5
	<10 (<10)	**<12 (<12-14)**	<14 (<14)	<12 (<12)	>13 (<13)	<15 (<15)
Eggs	7.0	7.5	**11**	7.0	8.0	9
	<14 (<14)	<15 (<15)	**<16 (<16-25)**	<14 (<14)	<16 (<16)	<18 (<18)
Fats, oils	5.0	6.0	7.0	6.0	6.5	7.5
	<10 (<10)	<12 (<12)	<14 (<14)	<12 (<12)	>13 (<13)	<15 (<15)
Vegetables	4.0	1.5	4.5	5.0	5.5	5.0
	<8.0 (<8.0)	<3 (<3)	<9.0 (<9.0)	<10 (<10)	<11 (<11)	<10 (<10)
Fruits	4.0	1.5	4.5	5.0	5.5	5.0
	<8.0 (<8.0)	<3 (<3)	<9.0 (<9.0)	<10 (<10)	<11 (<11)	<10 (<10)
Potatoes	4.0	1.5	4.5	5.0	5.5	5.0
	<8.0 (<8.0)	<3 (<3)	<9.0 (<9.0)	<10 (<10)	<11 (<11)	<10 (<10)
Sugar sweets	5.5	6.0	5.5	5.5	6.0	5.0

	<11 (<11)	<12 (<12)	<11 (<11)	<11 (<11)	<12 (<12)	<10 (<10)
Beverages	5.0	6.0	7.0	6.0	6.5	7.5
	<10 (<10)	<12 (<12)	<14 (<14)	<12 (<12)	>13 (<13)	<15 (<15)
N<LOQ (%)	55 (92)	54 (90)	55 (92)	59 (98)	57 (95)	60 (100)

11.10.3 Exposure estimation

Due to the few samples with concentrations above LOQ the difference between lower-bound and upper-bound total per capita intake was substantial except for PFHxA, linear PFOA, linear PFOS, and linear PFOSA (Table 11.10:10). For these PFAS median lower-bound and upper-bound intakes differed not more than 5-fold. The highest lower-bound intake was observed for linear PFOSA (median 22 ng/day) followed by linear PFOS (14 ng/d) and linear PFOA (12 ng/d). PFHxA, PFNA, PFDA, PFUnDA, PFTrDA and branched PFOS all had lower-bound median intakes less than 10 ng/d.

Table 11.10:10. Total per capita intake of PFAS (ng/day). In lower-bound calculations concentrations in individual baskets below LOQ was set to zero, in upper-bound calculations they were set to the LOQ concentrations.

Compound	Lower-bound	Upper-bound
PFBA	0 (0-0)	54 (54-54)
PFPeA	0 (0-0)	51 (51-51)
PFHxA	4.0 (3.7-8.0)	21 (20-23)
PFHpA	0 (0-0)	20 (20-20)
l-PFOA	12 (9.7-13)	27 (26-29)
br-PFOA	0 (0-0)	23 (23-23)
PFNA	1.6 (1.1-1.9)	21 (21-22)
PFDA	2.2 (1.5-7.2)	22 (21-22)
FPUnDA	6.0 (2.8-7.6)	30 (27-32)
PFDoDA	0 (0-2.6)	23 (23-25)
PFTrDA	1.0 (0-2.5)	26 (25-27)
PFTeDA	0 (0-0)	26 (26-26)
PFBS	0 (0-0)	15 (15-15)
l-PFHxS	0 (0-4.1)	16 (16-18)
br-PFHxS	0 (0-0)	18 (18-18)
l-PFOS	14 (13-20)	29 (27-34)
br-PFOS	0.80 (0-2.0)	18 (18-19)
PFDS	0 (0-0)	15 (15-15)
l-PFOSA	22 (0-35)	35 (13-48)
br-PFOSA	0 (0-0.90)	13 (13-14)

The fish baskets gave large contributions to the lower-bound per capita intake of PFNA, PFDA, PFUnDA, PFTrDA, linear and branched PFOS, and linear PFOSA, with median contributions over 70% (Table 11.10:11). For PFDoDA and branched PFOSA

concentrations were above LOQ in only one or two fish baskets out of five, and in those cases they contributed 100% to the intake. For PFHxA vegetables gave the largest contribution to total per capita intake (>70%) and for linear PFOA cereals gave a median contribution of 50%. This shows that contamination pathways for PFHxA and PFOA differ, as well as from PFOS, PFOSA and the longer-chained PFCAs.

Table 11.10:11. Contribution of different food groups to the lower-bound total per capita intake (median (range)).

Compounds	Cereal pr. (%)	Pastries (%)	Meat (%)	Fish (%)	Dairy pr. (%)	Eggs (%)
PFHxA	0 (0-94)					0 (0-9.1)
l-PFOA	50 (35-62)	5.6 (0-32)	27 (0-31)	5.6 (0-8.5)		0 (0-4.7)
PFNA				100 (100-100)		
PFDA				100 (24-100)	0 (0-76)	
PFUnDA				100 (88-100)		0 (0-12)
PFDoDA				0 (0-100)		
PFTrDA				100 (0-100)		
l-PFHxS					0 (0-100)	
l-PFOS			19 (11-48)	71 (48-85)		0 (0-18)
br-PFOS				100 (0-100)		0 (0-14)
l-PFOSA	0 (0-27)			100 (0-100)		
br-PFOSA				0 (0-100)		

	Fats, oils (%)	Vegetables (%)	Fruits (%)	Potatoes (%)	Sugar sweets (%)	Beverages (%)
PFHxA	8.3 (0-13)	79 (0-92)	0 (0-30)			
l-PFOA	0 (0-5.3)				5.8 (5.3-8.7)	
PFNA						
PFDA						
PFUnDA						
PFDoDA						
PFTrDA						
l-PFHxS						
l-PFOS						
br-PFOS						
l-PFOSA						
br-PFOSA						

The market basket samples from 1999, 2005 and 2010 were also analysed, making it possible to investigate temporal trends in PFAS concentrations and total per capita intake. Temporal trend analyses of concentrations were focused on the food group giving the largest contribution to lower-bound total per capita intakes in 2015. For PFHxA, the vegetable baskets gave the largest contribution, and the median concentration decreased from above 60 ng/kg fresh weight in 1999 to less than 20 ng/g in 2015 (Fig. 11.10:1). Similarly, lower-bound per capita intakes of PFHxA decreased between 1999 and 2015, with a 4.5% decrease in intake per year in log-linear regression analyses (Table 11.10:12). This suggests that PFHxA intake from foods included in the market basket studies has declined since the late 1990s, although there still is some uncertainty due to concentrations below LOQ in all samples for seven out of 12 food groups. In studies of temporal trends of PFHxA in blood of first-time mothers and their children from Uppsala, PFHxA concentrations in blood serum were in most cases below LOQ (Gyllenhammar et

al., 2015; 2016), so conclusions cannot be drawn about temporal trends of total PFHxA exposure from all sources.

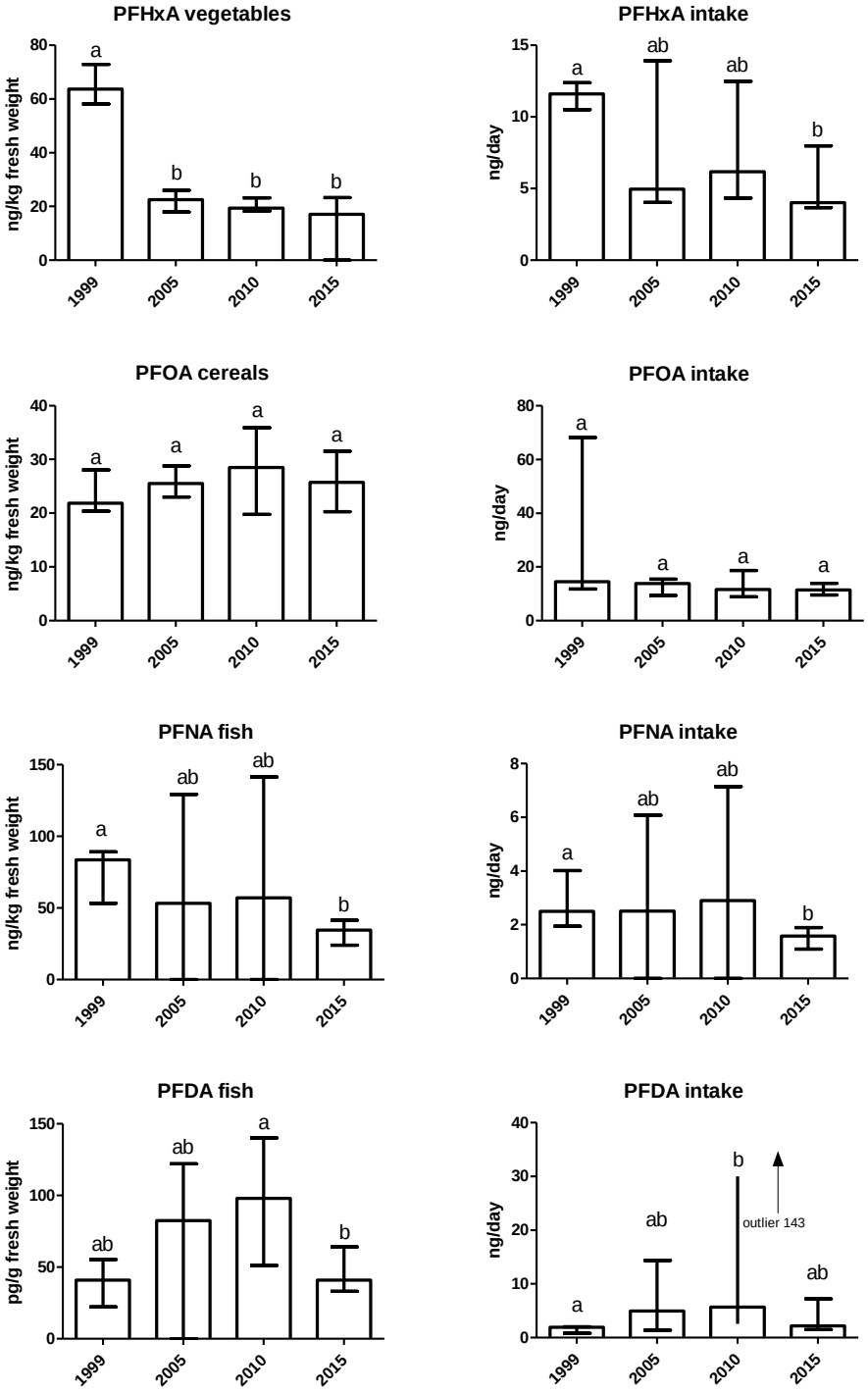


Figure 11.10:1. 1999-2015 PFCA concentrations in the MBs contributing most to the lower-bound total per capita intake in 2015, and lower-bound total per capita intake

(median, range). Statistically significant differences between years are shown with different letters above the bars (Mann-Whitney U-test, p ≤0.05, N=3-5).

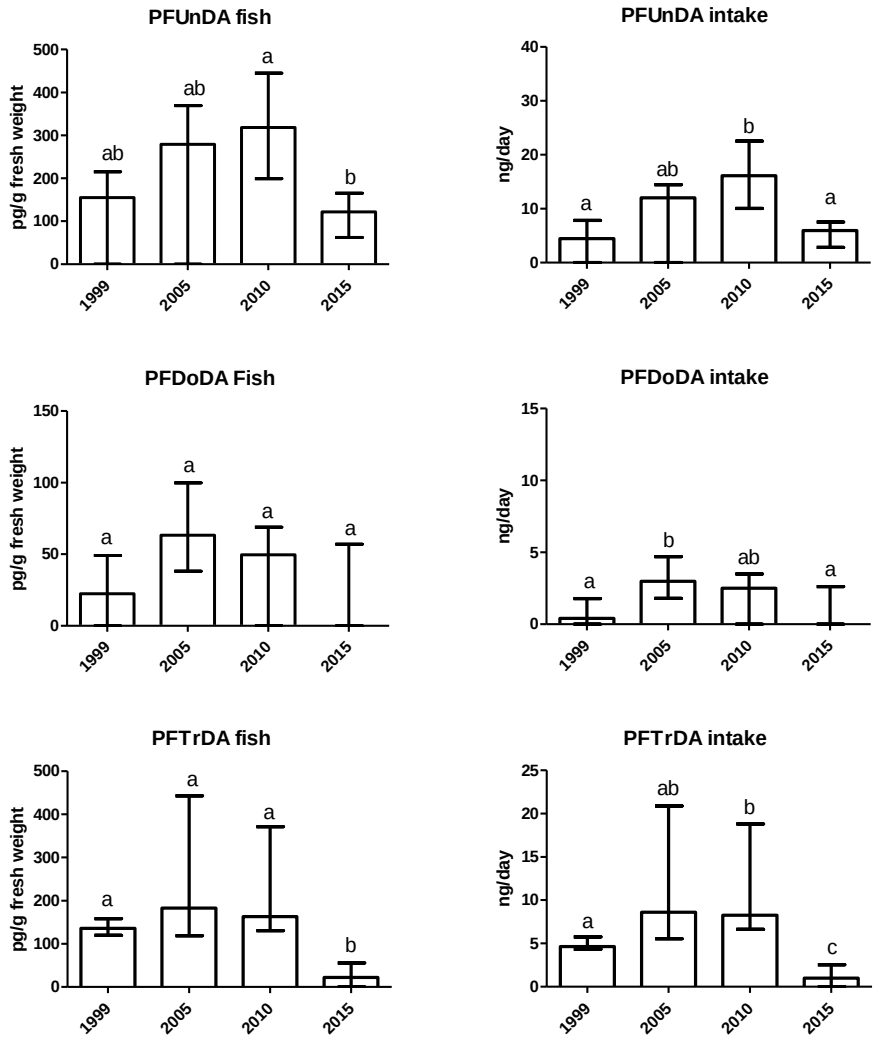


Figure 11.10:2. 1999-2015 PFCA concentrations in the MBs contributing most to the lower-bound total per capita intake in 2015, and lower-bound total per capita intake (median, range). Statistically significant differences between years are shown with different letters above the bars (Mann-Whitney U-test, p ≤0.05, N=3-5).

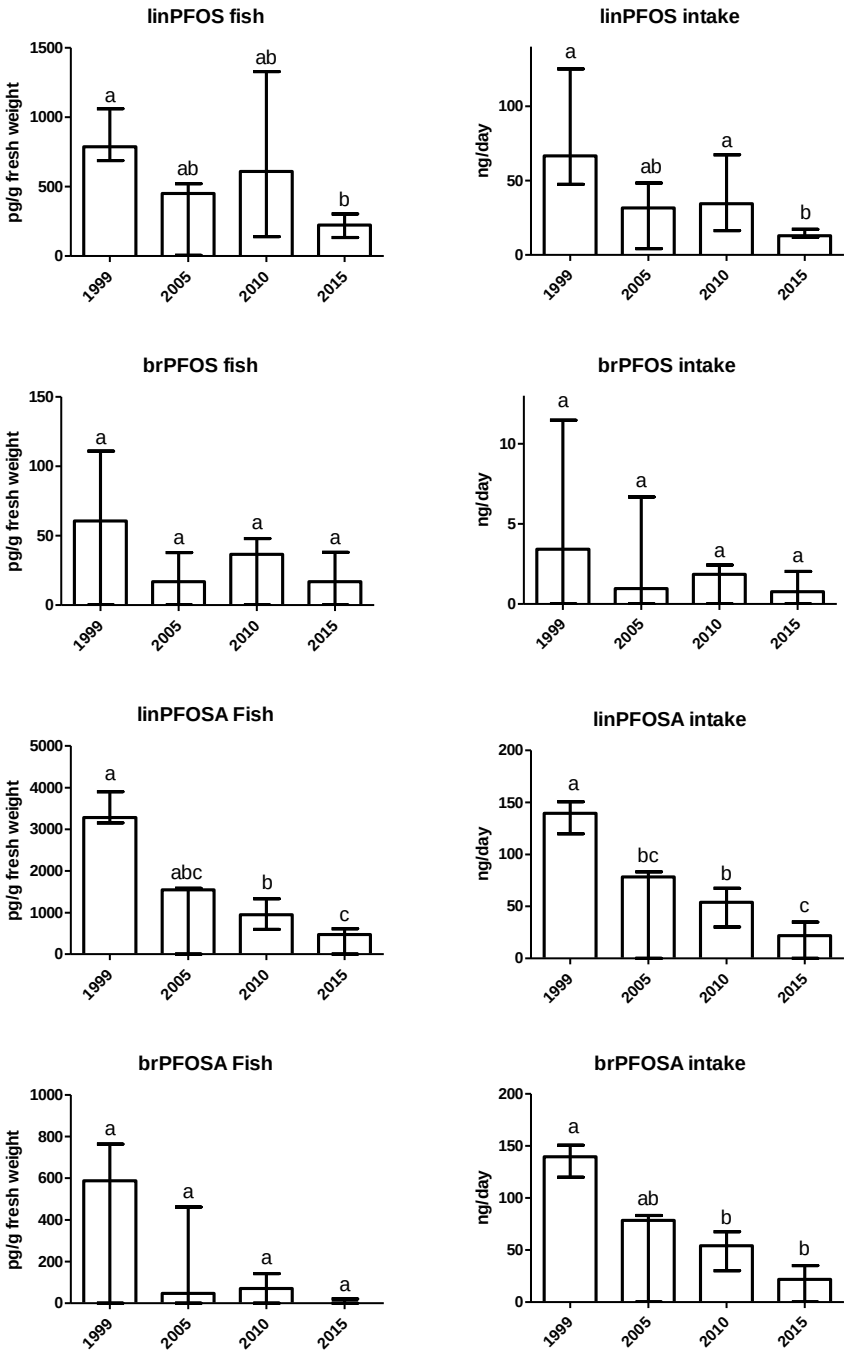


Figure 11.10:3. 1999-2015 PFSA and PFOSA concentrations in the MBs contributing most to the lower-bound total per capita intake in 2015, and lower-bound total per capita intake (median, range). Statistically significant differences between years are shown with different letters above the bars (Mann-Whitney U-test, $p \leq 0.05$, N=3-5).

Table 11.10:12. Temporal trends of lower-bound total per capita intake of PFAAs in market baskets 1999-2015, as estimated by log-linear regression analysis.

Compound	Temporal trend (% change/year)	P
PFHxA	-4.5±1.6	0.012
lin-PFOS	-9.6±1.6	<0.001
br-PFOS	-6.6±3.0	0.045
l-PFOSA	-20±5.6	0.002
br-PFOSA	-18±4.6	0.001

In cases when lower-bound total per capita intake was zero it was substituted with the lowest intake that year above zero.

No differences between median concentrations of PFOA in cereals and between intakes were observed 1999-2015 (Fig. 11.10:1). Biomonitoring studies have shown that human exposure to PFOA has decreased in Sweden (Axmon et al., 2014; Glynn et al., 2012; Sundström et al., 2011), most probably due to phase-out of production and use of PFOA and related substances by the biggest manufacturers (Lindstrom et al., 2011). Our results suggest that direct PFOA exposure from foods has not markedly contributed to the decline in PFOA exposure in Sweden.

Concentrations of other long-chain PFCAs in the fish baskets suggest non-linear trends with concentrations increasing between 1999 and 2010, followed by a decrease thereafter in 2015 (Figs. 11.10:1 and 11.10:2). In these cases, concentrations were lower in 2015 than in 2010, except for PFNA and PFDoDA. Per capita intakes 1999-2015 followed a similar trend with increasing intakes 1999-2010 and decreasing thereafter (Figs. 11.10:1 and 11.10:2).

For PFOS, the fish baskets contributed most to the total per capita intake in 2015. Median linear and branched PFOS concentrations decreased more than 2-fold between 1999 and 2015, although the decrease was not statistically significant for branched PFOS (Fig. 11.10:3). Log-linear regression analyses showed that lower-bound total per capita intakes of both branched and linear PFOS decreased, with about 10% per year for linear PFOS and 7% per year for branched PFOS (Table 11.10:12). This corroborates with the declined blood serum concentrations of both branched and linear PFOS in first-time mothers from Uppsala 1996-2012 (Gebbink et al., 2015).

PFOSA, which can be biotransformed to PFOS, seemed to decrease faster in the fish baskets than PFOS during the study period (Fig. 11.10:3). Log-linear regression analyses of total per capita intake of branched and linear PFOSA showed a 20% decline per year (Table 11.10:12). A similarly faster decline in blood serum PFOSA concentrations than of PFOS concentrations was observed in the Uppsala first-time mothers 1996-2010 (Glynn et al., 2012). The results strongly suggest that the contamination of fish with PFOS and related compounds on the Swedish market clearly has decreased since the

major manufacturer in North America phased out production more than a decade ago. This decrease has contributed to a declined total exposure to PFOS and related compounds, as shown by the temporal trends in blood serum from the Uppsala mothers (Gebbink et al., 2015).

Table 11.10:13. The quotients between health-based reference intakes for PFOS and PFOA, set by the US EPA in 2016, and the highest upper-bound total per capita intakes of PFOS and PFOA estimated for 2015.

Compound	Upper-bound per capita intake (ng/kg body weight/day)	Health-based reference intakes (ng/kg/d)	Quotient
lin-PFOS	0.44	20	45
lin-PFOA	0.41	20	49

Body weight 76.6 kg

11.10.4 Risk assessment

Health-based reference intakes are only available for PFOS and PFOA. In 2008 EFSA published tolerable intakes of the chemicals (EFSA, 2008b). For PFOS the tolerable daily intake (TDI) was set to 150 ng/kg body weight/day, based on studies in adult monkeys showing changes in thyroid hormone and cholesterol levels in blood. A safety factor of 300 was applied on the highest exposure not causing changes in the monkeys (NOAEL). TDI for PFOA, 1500 ng/kg body weight/day, was based on negative effects on livers of male offspring of female rats exposed during pregnancy. A safety factor of 200 was used on the exposure level causing an average 10% increase in liver damage (EFSA, 2008b).

US EPA published PFOS and PFOA reference doses (Rfds) for the development of a drinking water guideline in 2016 (EPA, 2016a,b). Decreased birth weights of rat pups exposed in utero was the most sensitive toxic effect of PFOS, and after toxicokinetic extrapolation between rats and humans and the use of a safety factor of 30 on the NOAEL a Rfd of 20 ng/kg body weight/day for the life-time before pregnancy was reached. For PFOA the Rfd was based on developmental effects on rat offspring exposed in utero. After toxicokinetic extrapolation between rats and humans and a safety factor of 300 on the lowest exposure level causing toxic effects (LOAEL) a Rfd of 20 ng/kg body weight/day for the life-time before pregnancy.

In the present risk assessment the US EPA Rfds are used since they are based on a more updated knowledge base than the EFSA TDIs. The highest estimated upper-bound total per capita intake of linear PFOS was 45 times lower than the Rfd using a body weight of 76.6 kg (Table 11.10:13). For linear PFOA the margin was even larger being 53 times lower than the Rfd. Even in the worst-case scenario, if the highest estimated total per capita intake of branched isomers of PFOS and PFOA is included, the margin would be more than 20-fold below the Rfds. The Rfds are most relevant for young women who

may become pregnant in the future. Using a body weight of 60 kg instead of 76.6 kg lowers the margin to the Rfds but the margin is still large.

11.10.5 Conclusion

The diverging patterns of PFAS contamination of foods show that there are differences in contamination pathways in the food production chain. In the 2015 basket, PFHxA and PFOA exhibited a more general contamination of several food groups whereas long-chain PFCAs and PFOS and related compounds mostly were found in the fish baskets. Differences in patterns of use in commercial products and bioaccumulative properties after emissions into the environment may explain some of the differences in contamination patterns observed (Conder et al., 2008; Lindstrom et al., 2011).

Analyses of temporal trends of lower bound total per capita intakes also showed diverging results which could be due to compound-specific differences in changes of production and use. For instance, phase-out of production of PFOS and related compounds has resulted in clear decreases in food contamination, whereas this is not evident for PFOA. This could be because production of PFOS and related compounds was phased out within a much shorter time period in early 2000s than PFOA (Lindstrom et al., 2011). PFASs mainly accumulating in fish showed diverging temporal trends between 1990 and 2015, with PFOS contamination decreasing and long-chain PFCAs showing increased contamination during the first decade and thereafter a drop in contamination. This suggests homologue differences in temporal changes in pollution of the aquatic environment world-wide.

The margin between the estimated maximum upper-bound total per capita intake of PFOS and PFOA and the US EPA RfDs was at least 20-fold. Rfds are based on toxicological data from animal studies, and consequently there is a large margin between the average direct PFOS and PFOA exposure from food on the Swedish market and exposure levels causing adverse toxic effects in animals. However, drinking water is contaminated with PFOS and PFOA in some parts of Sweden, and in some cases intake from drinking water totally overshadows intake from food (Jakobsson et al., 2014; Forsell et al., 2016). Moreover, certain inland water systems are contaminated with PFOS, resulting in very high concentrations in freshwater fish and much higher PFOS intakes than from other foods (Berger et al., 2009; Houde et al., 2011).

No health-based guide-line values have been published for the other studied PFASs. Moreover, it is currently not possible to risk assess human exposure to the total PFAS mixture. According to the Swedish Chemicals Agencies, there are over 3000 different commercially available PFASs on the global market (Swedish Chemicals Agency, 2015) and currently we only have knowledge about human exposure to a few of these PFASs.

11.11 Polycyclic aromatic hydrocarbons (PAHs)

11.11.1 Background

Polycyclic aromatic hydrocarbons (PAHs) are formed during incomplete combustion processes, whenever wood, coal or oil is burnt. They can therefore be found in complex mixtures throughout the environment, also including a variety of foodstuffs. Food can be contaminated from environmental sources, industrial food processing and during home food preparation (Howard et al., 1969; Moret and Conte, 2000; Simko, 2002). Specific practices such as barbecuing can give rise to high PAH level in the food (Rose et al., 2015).

As PAHs represent an important class of carcinogens their presence in food should be as low as possible. The EU Scientific Committee on Food (SCF) has identified 15 PAHs which are of major concern for human health (EFSA, 2002; EFSA, 2008c). Particular attention has been paid to the highly carcinogenic benzo[a]pyrene (Phillips, 1983). Maximum levels of benzo[a]pyrene (BaP) and the sum PAH4 (benz(a)anthracene, BaP, benzo(b)fluoranthene and chrysene) in a range of foodstuffs are specified in a Commission Regulation, EU 835/2011.

11.11.2 Chemical analysis

Composite samples were prepared from equal amounts of samples from the five different food chains, for each of the food groups that were analysed for PAH (see Table 11.11:1). The composite samples were stored in a freezer until analysed in July 2015 at NFA, Sweden. The samples were analysed according to a GC/MS method described elsewhere (Wretling et al., 2010) with some modifications. Briefly, samples from the food groups were spiked with perdeuterated PAHs as internal standards and saponificated in methanolic KOH solution at 70°C. The samples were subsequently extracted with cyclohexane and washed several times with a mixture of methanol and water. Thereafter, samples were cleaned-up on two sets of SPE columns and injected in an Agilent 6890 gas chromatograph connected to an Agilent 5975 mass selective detector. A 30m DB-35ms fused silica column was used for separation. This column can separate chrysene from triphenylene which is of great importance for the parameter PAH4. The analytical method complies with the criteria for official control of BaP according to Commission Regulation (EC) No 333/2007.

Analytical quality control

The method is accredited against ISO 17025 by SWEDAC for 25 PAHs, phenanthrene (Phe), anthracene (Ant),fluoranthene (Flu), pyrene (Pyr), benzo(c)fluorene (BcL), cyclopenta[c,d]pyrene (CPP), **benz[a]anthracene (BaA)**, triphenylene (TP), **chrysene (CHR)**, 5-methylchrysene (5MC), **benzo[b]fluoranthene (BbF)**, benzo[k]fluoranthene (BkF), benzo[j]fluoranthene (BjF), benzo[e]pyrene (BeP), **benzo[a]pyrene (BaP)**, Perylene (Per), dibenz[a,h]anthracene (DhA), indeno[1,2,3-cd]pyrene (IcP), benzo[g,h,i]perylene (BgP), anthantrene (ATR), dibenzo[a,l]pyrene (DlP), dibenzo[a,e]pyrene (DeP), dibenzo[a,i]pyrene (DiP), dibenzo[a,h]pyrene (DhP) and

Coronene (Cor) (Sum PAH4 substances in bold). The trueness of the method is proven by using certified reference materials and participating in proficiency tests before, during and after the time of analysing. For the daily quality control an in-house control sample, maize oil, runs with each batch of samples. The limit of detection (LOD) is calculated to 0.03 µg/kg.

11.11.3 Analytical results

In Table 11.11:1 results above LOD for BaP, BaA, BbF, CHR and the sum of PAH4 are presented. In general the levels of PAHs are low. The highest levels for the sum PAH4 were found in fats (0.51 µg/kg f.w.) and sugar/sweets (0.48 µg/kg f.w.) followed by pastries, fish/fish products, processed meat and cereals. The levels for the meat/meat products, vegetables and fruit samples were under the quantification limit (LOQ 0.03 µg/kg f.w.)

Table 11.11:1. PAH levels (µg/kg ± MU) in composite samples from 9 of the 12 food groups collected 2015.

Food Group	BaA	CHR	BbF	BaP	∑PAH4
Cereal products	0.03 ± 0.005	0.04 ± 0.01	0.03 ± 0.005	<0.03	0.10 ± 0.01
Pastries	0.05 ± 0.01	0.08 ± 0.01	0.06 ± 0.01	0.05 ± 0.01	0.24 ± 0.02
Meat	<0.03	<0.03	<0.03	<0.03	<0.03
Processed meat	0.06 ± 0.01	0.06 ± 0.01	<0.03	0.03 ± 0.005	0.17 ± 0.01
Fish	0.05 ± 0.01	0.05 ± 0.01	0.03 ± 0.005	0.03 ± 0.005	0.16 ± 0.01
Fats and oils	0.11 ± 0.02	0.15 ± 0.02	0.13 ± 0.02	0.12 ± 0.02	0.51 ± 0.04
Vegetables	<0.03	<0.03	<0.03	<0.03	<0.03
Fruits	<0.03	<0.03	<0.03	<0.03	<0.03
Sugar and sweets	0.13 ± 0.02	0.16 ± 0.02	0.10 ± 0.02	0.09 ± 0.01	0.48 ± 0.03

11.11.4 Exposure estimation

Analysis of the PAH content in nine different food groups, included in the MB 2015 study, gave about the same result as the two earlier MB studies, i.e. in the year of 1999 and 2010 (NFA, 2012). Concerning the intake of BaP in 2015, the per capita intake via food was estimated to a mean of about 32 µg/person and day. In the 2010 and 1999 surveys the BaP intakes were calculated to 33 and 40 µg/person and day, respectively (NFA, 2012). However, since the estimation was not made in the same way in the different years, 1999, 2010, and 2015, it is difficult to in a correct way compare the total intake of PAH between the different years. For example, in the 2010 survey, the BaP levels in the food groups of vegetables and fruits were below the limit of quantification, LOQ, and thereby calculated as zero. Although it is difficult to compare the PAH intake for the different years of survey, it is obvious that the PAH intake from several food categories (e.g. cereal products, pastries, meat) is lower today, which depends on the PAH levels in the food, not due to an decreased consumption.

There are different ways of estimating intake of chemicals. How to handle with concentrations below quantification, LOQ, is open for discussion. In this study we have estimated it in two ways; a) by simply approximate the levels to be ½LOQ and, b) by use of the estimated instrument signal for values under LOQ. In Table 11.11:2 we have presented an intake estimation based on instrument signal of PAH levels. If the LOQ level is high and the concentration is low, it may result in big differences between the two practices for intake calculations. However, in this study the two ways of calculating the PAH intake results in only a small difference (data not shown).

Table 11.11:2. Exposure to BaP and PAH4 in the Swedish population 2015.

Group no.	Food group	consump-tion (gx10^2/ year)	consump-tion (g/ day)	BaP (µg/kg food)	BaP exposure (ng/person, day)	PAH4 (µg/kg food)	PAH4 exposure (ng/person, day)
1	Cereal products	836	229	*0.02*	4.58	*0.12*	27.5
2	Pastries	177	48	0.05	2.4	0.24	11.5
2u	*Subgroup*	70	19	n.a.			
3	Meat	774	212	*0.01*	2.12	*0.06*	12.7
3u	*Subgroup*	207	57	0.03	(1.71)	(0.17)	(9.69)
4	Fish	167	46	0.03	1.38	0.16	7.36
5a	Dairy prod., fluids	1180	323	n.a.			
5b	Dairy prod., solids	290	79	n.a.			
6	Eggs	101	28	n.a.			
7	Fats and oils	164	45	0.12	5.4	0.51	23,0
8	Vegetables	721	198	*0.01*	1.98	*0.03*	5.94
9	Fruits	851	233	*0.01*	2.33	*0.05*	11.6
10	Potatoes	461	126	n.a.			
11	Sugar and sweets	459	126	0.09	11.3	0.48	60.5
12	Beverages	1150	315	n.a.			
Total					31.5		160

Notes. The figures written in Italic style indicate that the levels were below the limit of quantification (LOQ) but above the detection limit (LOD). Instead of approximate all these levels as ½ LOQ an estimate from the instrument signal of the level was made. These values are more uncertain than the ones above LOQ but could be used to avoid an over estimation when all or most of the results are <LOQ.

n.a.= not analysed

11.11.5 Risk assessment

The main concern regarding possible health effects of BaP, is its carcinogenicity (DNA-damaging effect). It causes increased levels of tumors in laboratory mammals after lifelong exposure. BaP is a well-studied compound and classified by the WHO organ IARC (International Agency Research on Cancer) as a human carcinogen and by an ”overall evaluation upgraded to Group 1 based on mechanistic and other relevant data” (IARC, 2012). Therefore it is assumed that there is no dose level without any increased health effect. Because of the carcinogenicity, due to DNA-damaging effects, no tolerable dose (TDI) can be postulated. Consequently, a lowering of the exposure is always a lowering of the risk of tumor incidence.

There are also other PAHs which have been demonstrated as genotoxic, some of these are benz(a)anthracene, chrysene, and benzo(b)fluoranthene (JECFA, 2005; IARC, 2010; Abramsson-Zetterberg and Maurer, 2015). Together with BaP they are named PAH4 in this text. As a consequence of their genotoxicity, it is important to estimate the levels in food and also the intake. Because of the genotoxic property and the carcinogenic effect, maximum levels in some food stuffs have been decided for all four PAHs mentioned above - according to the Commission Regulation, (EC, 2007).

When comparing the BaP and PAH4 concentrations in food, it shows that Fats and oils contribute with the highest level. But, concerning intake, Sugar and sweets, contributes with the highest part (Fig 11.11:1 and :2). The explanation to this is our eating habits. In comparison with 1999 our consumption of Sugar and sweets has increased with about thirty per cent. Although the PAH level in Cereals is low, our cereal intake constitutes a great part of our daily intake of PAH, about 15%. This is of course due to our high consumption of cereal products, e.g. bread.

JECFA concluded in their 64th meeting in Rome, 2005, that B(a)P could be used as a marker in the evaluation of PAHs in food and thereby used in the evaluation of cancer risk. A mean intake of B(a)P of 280 ng/person and day corresponds to a MOE (margin of exposure) of 25 000 (JECFA, 2005). A MOE of 25 000 means that the intake of B(a)P among people is 25 000 times lower than the dose which in animal studies have resulted in an estimated increased cancer risk of ten percent.

Based on this evaluation and a linear extrapolation from higher doses, the calculated mean intake of B(a)P in Sweden, about 30 ng/person and day, corresponds to a MOE of about 200 000, meaning that it is likely that about five persons out of ten millions get cancer during their life time because of B(a)P in food.

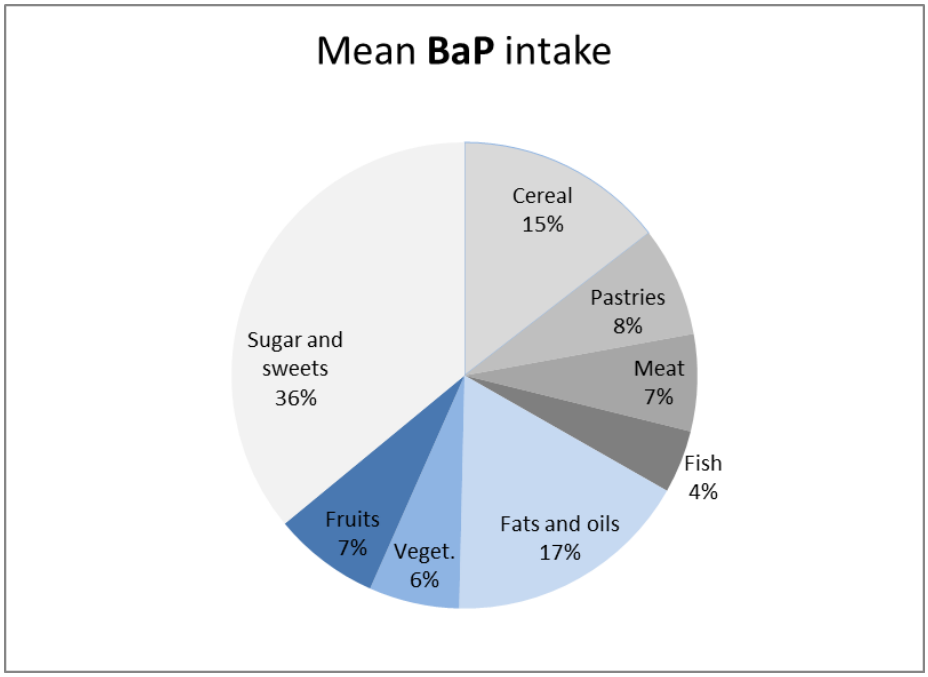


Fig 11.11:1. The proportion of the mean exposure of benzo[a]pyrene (BaP) in some of the different food groups.

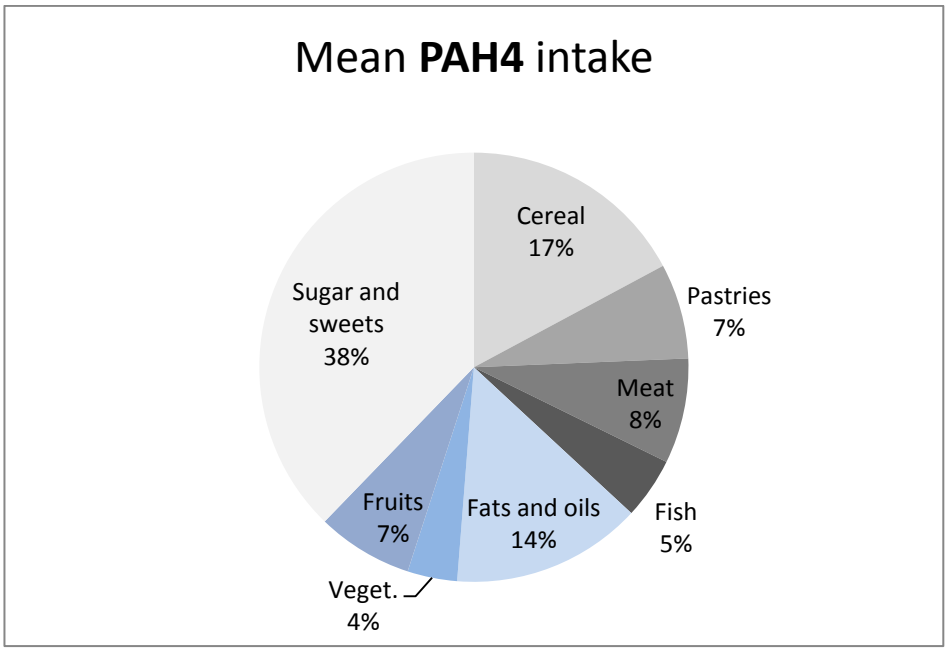


Fig11.11:2. The proportion of the mean exposure of PAH4 (benz(a)anthracene, benzo[a]pyrene , benzo(b)fluoranthene and chrysene) in some of the different food groups.

11.11.6 Conclusion

In comparison with the B(a)P and PAH4 levels in Sweden fifteen years ago, using about the same selection of food for analysis, the content as well as the estimated total intake has decreased today. This decrease is neither due to more sensitive analythical methods, nor to an apparent change in consumption pattern, but to a lower PAH content in food. The lower PAH levels in food may be a result of improved production processes and probably also due to lower PAH levels in air.

Today B(a)P and PAH4 in food are of low concern for human health in Sweden.

11.12 Phenolic compounds

11.12.1 Background

Phenolic compounds is a group of substances of both synthetic and natural origin. Most often phenolic compounds are present in our environment in pharmaceuticals, personal-care products (e.g. surfactants and synthetic fragrances), preservatives, pesticides and miscellaneous industrial chemicals and by-products (e.g. in plastic industry) (Basile et al., 2011; Calafat et al., 2008). As such, they might be additives or contaminants from the environment or food packaging material and can be found in food and beverages. Many phenolic compounds may have the ability to affect the human endocrine system and are collectively termed endocrine disrupting compounds (EDCs). EDCs are substances that "interfere with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body that are responsible for the development, behavior, fertility, and maintenance of homeostasis" (Adamusova et al., 2014). EDCs are still not regulated at the EU level, but the work is ongoing to develop scientific criteria and properties for regulation.

This report is focused on analysis of a selected number of relevant phenolic compounds that could be found in food (Table 11.12:1).

11.12.2 Chemical analysis

Phenolic compounds were studied in market basket samples from previous MB surveys (1999, 2005 and 2010). Analyses were carried out by IVL (Swedish Environmental Research Institute), where up to 11 compounds that could be quantitatively measured were included in the analysis. To develop new analytical methods by which also the earlier results could be verified a new method was set up in-house and applied for analysis of an extended number of phenolic compounds with high sensitivity (LOD <0.1 ng/g). The method is an UPLC-ESI-MS/MS based multianalyte method that applies multiple reaction monitoring (MRM) and isotope labelled internal standards for quantitative determination of phenolic compounds (Table 11.12:1). A portion of 5 g of homogenized sample is used and the extraction is performed by shaking the sample with solvent followed by dehydration, clean-up, evaporation/dissolution and filtration prior to injection into the UPLC-MS/MS system. The method is not validated yet and the findings from the analysis of some of the samples from MB are further discussed in section 11.12.3 below.

Table 11.12:1. Phenolic compounds included in the analytical method used at NFA and the corresponding isotope labelled internal standards (IS) for quantitative determination. The most similar IS was used for compounds without matching IS. Compounds marked with asterisk were analysed (by IVL) in previous MB surveys.

Phenolic compound	Internal standard
Methylparaben, MP	Methyl 4-hydroxybenzoate-2,3,5,6-d4
Ethylparaben, EP	
4-Bromophenol, 4-BrP*	4-Bromophenol-2,3,5,6-d4
2,4- Dibromophenol, DBP*	
2,4,6- Tribromophenol, TBP*	
3-tert-Butyl-4-hydroxyanisole, BHA*	
2,6- Di-tert-butyl-4-methylphenol, BHT*	
Bisphenol A, BPA*	Bisphenol A-d16
Bisphenol F, BPF	
Bisphenol S, BPS	
4-tert-butylphenol, 4-t-BP*	4-tert-Butyl-d9-phenol-2,3,5,6-d4
4-tert-oktylphenol, 4-t-OP*	
4-Nonylphenol, NP*	4-Nonylphenol-2,3,5,6-d4
Benzophenone-3, BP-3	2-Hydroxy-4-methoxybenzophenone-2',3',4',5',6'-d5
Triclosan, TC*	
Pentaclorophenol, PCP*	Pentachlorophenol-$^{13}C_6$

11.12.3 Discussion of the analytical results

An estimation of the dietary contribution to the intake of phenolic endocrine disruptors requires reliable analytical data. Since this type of substances are in many cases very widespread in the environment there is a major risk that their levels measured in samples, in whole or in part, are a result of undesired contamination during the various steps from sampling to analysis.

Our experience, from the work with the analytical method development, is that the ubiquitous presence of some of these chemicals in the environment (i.e., bisphenol A (BPA), methyl- and ethylparaben (MP, EP), 4-tert-oktylphenol (4-t-OP) or benzophenone-3 (BP-3)), represents an external contamination source that substantially contributes during sample handling and analysis. Consequently, this compromises the found concentrations of such chemicals in the samples collected for quantitative evaluations. An investigation of various individual sources of contamination was implemented in order to reduce and stabilize the contamination levels before the validation of the method starts. The, until now, identified contamination sources were solvents and reagents, the background in the experimental apparatus used and the materials present in our laboratory environment including gloves (4-t-OP) and tissue

paper (MP and BPS). A potential contamination source not to be forgotten is also the analyst, as it is not unusual that personal care products often contain i.e. parabens and BP-3 (Bledzka et al., 2014; Calafat et al., 2008; Commission Regulation (EU) No 1004/2014). Table 11.12:2 shows values of five of the phenolic EDCs concentrations found by NFA in the mixed matrix sample of the cereal category after preventive measures to reduce the until now known external contamination sources in our laboratory were implemented. The found levels of these five compounds were clearly higher than in the reagent blank (RB) while the levels of the other compounds might only be the undesired contamination from the laboratory environment.

Table 11.12:2. Approximate concentrations of phenolic compounds found in food category cereals. External calibration and subtraction of the background (RB) were applied. Concentrations of the compounds found by IVL in previous MB surveys are shown in the right column.

Phenolic compound	Concentration (ng/g), NFA	Concentration (ng/g), IVL
MP	0.9	na
EP	3.9	na
4-BrP	nd	0.03
DBP	nd	<0.03
TBP	nd	0.1
BHA	nd	0.1-0.5
BHT	na	0.6-6.8
4-t-BP	18	0.03-0.4
4-t-OP	nd	<2
NP	1.5	16-30
BPA	0.2	<1
BPF	nd	na
BPS	nd	na
TC	nd	<0.1-0.2
PCP	nd	0.8-1.2

Since the analytical method is not validated yet and the complete integrity of the samples, with regard to the external contamination of phenolic compounds, cannot be assured, the quantities given in the table are approximate.
nd, not determined (found at the same level as in the reagent blank); na, not analysed

For quantitative determination data to be valid, even when obtained from a well-working analytical method and good laboratory practice, the analyses therefore require stringent validation and quality assurance. The practices that unconditionally have to be followed to identify and track the unintended contaminations with the target analytes during analysis are: the quality control measures including use of blanks, replicate analysis, clean rooms adapted for the current analytical purpose, and homogeneous matrix-matched quality control samples (blank and spiked at concentration level expected for the study samples).
When laboratory contamination cannot be avoided completely, the concentration of study samples needs to be adjusted by subtracting the concentartions in the reagent blanks. Still, a prerequisite for obtaining reliable quantitative data by blank subtraction is that the contamination can be controlled and reduced to stable levels as far as possible below the "true" levels in the survey samples.

11.12.4 Exposure estimation

No data to present

11.12.5 Risk assessment

No data to present

11.12.6 Conclusion

To conclude, according to our present experience, the analysis of phenolic compounds at low concentration levels in mixed and complex food matrices using regular analytical methods and laboratory equipment seems to be practically unfeasible until all possible sources of these chemicals in laboratory environment are identified and maximally reduced. This must be done to minimize their recurrence and impact on the analysis, in order to assure the validity of the data. The present focus of the study is the final method validation work that proceeds in parallel with the evaluation of the stability of the undesired contamination levels found so far.

11.13 Chlorinated paraffins

11.13.1 Background

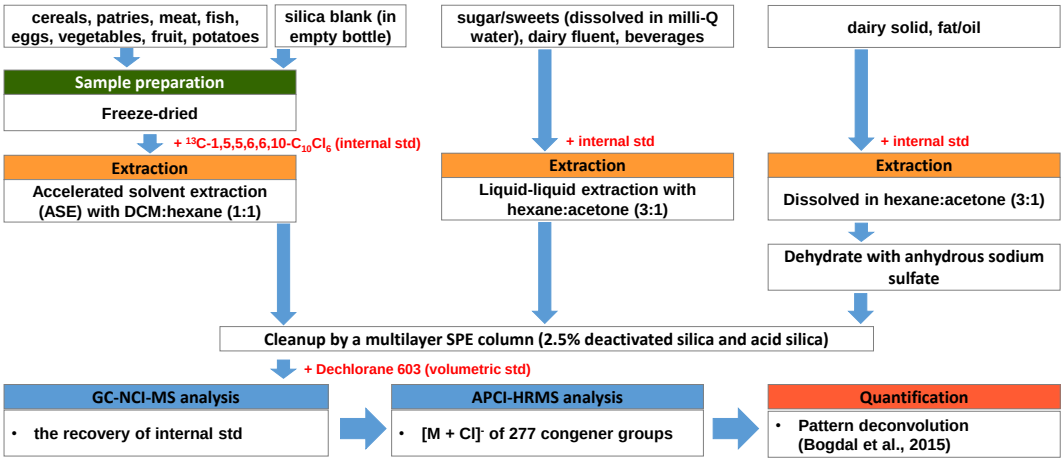
Chlorinated paraffins (CPs), or chlorinated alkanes, are a group of synthetic compounds produced by chlorination of straight-chained paraffin fractions. CPs have industrial applications as plasticizers, industrial metalworking fluids for cutting and drilling, and metal stamping in metal manufacturing. They are also used in paints, lathers, textiles and sealing compounds. EU production of CPs has rather recently been estimated to between 1 500 and 2 500 tons (Fiedler, 2010). However, the main producer today is China. In the 1980s, the CP production increased rapidly due to high demand from the plastic industry, and from that a strong increasing trend in production volumes has led to today's huge production of about 1 million tons (Glüge et al., 2016).

As a result of the wide industrial applications, CPs have been found as contaminants in the environment, for example in fish and aquatic food webs. The presence and persistence of CPs in the environment and observed adverse effects in animal models has prompted regulatory authorities and environmental organizations to decrease and regulate the industrial use of CPs. As an example, the Stockholm Convention has proposed short-chain CPs (SCCPs) as a new POP for the Stockholm Convention list of unwanted chemicals (now 22 POPs) (Stockholm Convention, 2017). Because of analytical difficulties, few CP studies on levels in humans and in food have been performed, and still today the analysis of CPs in biota is challenging. In this report we present for the first time data on CP levels in Swedish food and an estimation of the total mean intake of CPS via food consumption.

11.13.2 Chemical analysis

The extraction and cleanup process was adapted from previous studies (Zhou et al., 2016; Yuan et al., 2017). A method overview is shown in Figure 11.13:1. Prior to extraction, the samples were spiked with 10 ng of $^{13}C_{10}$-1,5,5,6,6,10-hexachlorodecane as the internal standard. The extracts were cleaned-up on a multilayer SPE column packed with 2 g silica (deactivated with 2.5% H_2O), 8 g 44% sulfuric acid silica and 4 g of anhydrous sodium sulfate from bottom to top. The concentrated extract was loaded and eluted by 30 mL of hexane and 10 mL of hexane/diethyl ether (1:1, v/v). The second eluent was concentrated and solvent exchanged to isooctane.

Figure 11.13:1. Method overview of chlorinated paraffin analysis



A set of 44 technical CP products and reference standards was initially analyzed, and a sub-set of eight standards was selected for quantification in this study.

CPs were measured using an atmospheric pressure chemical ionization high resolution mass spectrometer (APCI-HRMS) (Bogdal et al., 2015; Yuan et al., 2016). A total of 454 *m/z* ratios corresponding to 227 CP congener groups from C_9Cl_3 to $C_{31}Cl_{12}$ were considered to form a congener group pattern. The contribution of each CP congener group was calculated as the sum of the two instrument responses corresponding *m/z* ratios of the congener group. The total response of CPs was calculated as the sum of contributions from all individual congener groups. The congener group patterns, as well as the total response factors, of the selected products were measured for quantification. The recovery of ^{13}C-labelled CP congener standard was measured using a GC-MS.

CP response factor of each sample was calculated by a pattern-deconvolution algorithm which has been given in Bogdal et al. (2015). CP congener group pattern of each sample was reconstructed from CP patterns of the selected standards. The reconstructed pattern was compared to the initial pattern of the analyzed sample to determine the goodness of fit (R^2).

The recoveries of the ^{13}C-labelled CP congener standard are higher than 80% except for diary fluent sample. All sample values were blank subtracted. Method detection limits (MDLs) are given in Table 11.13:1.

Table 11.13:1. Recoveries, analyzed amounts and MDLs of CPs

Sample ID	Food group	recovery	sample extracted (g wet weight)	MDL (ng/g wet weight)		
				SCCPs[1]	MCCPs[2]	LCCPs[3]
Pool 1	Cereal prod.	117%	11.8	1.1	1.1	0.04
Pool 2	Pastries	121%	7.1	1.8	1.8	0.07
Pool 3	Meat	115%	13.1	1.0	1.0	0.04
Pool 4	Fish	88%	15.9	1.1	1.1	0.04
Pool 5A	Dairy prod., fluids	25%	31.7	2.0	2.0	0.08
Pool 5B	Dairy prod., solids	98%	7.9	2.0	2.1	0.08
Pool 6	Eggs	111%	10.4	1.3	1.4	0.05
Pool 7	Fats, oils	119%	2.3	5.7	5.7	0.22
Pool 8	Vegetables	98%	27.8	0.57	0.58	0.02
Pool 9	Fruits	149%	22.4	0.47	0.47	0.02
Pool 10	Potatoes	114%	18.3	0.75	0.76	0.03
Pool 11	Sugar, sweets	112%	15.5	0.90	0.91	0.03
Pool 12	Beverages	99%	30.9	0.51	0.52	0.02
(empty bottle)	(silica blank)	80%				

1= short-chain CPs,; 2=medium-chain CPs; 3=long-chain CPs

11.13.3 Analytical results

Chlorinated paraffins (CPs) were analyzed in 13 pooled food samples collected in 2015. Concentrations and chlorine contents of short-chain (C_9 - C_{13}, SCCPs), medium-chain (C_{14} - C_{17}, MCCPs) and and long-chain (C_{18} - C_{31}, LCCPs) CPs are shown in Table 11.13:2. The concentrations were close to or below the method detection limits (MDLs). Mean and standard deviation of recoveries of the isotopically-labelled internal standards were 103% ± 28%.

Table 11.13:2. Concentrations and chlorine contents of chlorinated paraffins in Swedish market basket samples (2015).

Sample ID	Food group	recovery	Concentration (ng/g wet weight)				Chlorine content (weight/weight)		
			Total CPs	SCCPs	MCCPs	LCCPs	SCCPs	MCCPs	LCCPs
Pool 1	Cereal prod.	117%	nd	<MDL	<MDL	<MDL	nd	nd	nd
Pool 2	Pastries	121%	4.3	<MDL	4.3	<MDL	nd	49%	nd
Pool 3	Meat	115%	nd	<MDL	<MDL	<MDL	nd	nd	nd
Pool 4	Fish	88%	9.7	4.6	5.1	<MDL	59%	50%	nd
Pool 5A	Dairy pr.,fluent	25%	nd	<MDL	<MDL	<MDL	nd	nd	nd
Pool 5B	Dairy pr., solid	98%	nd	<MDL	<MDL	<MDL	nd	nd	nd
Pool 6	Eggs	111%	nd	<MDL	<MDL	<MDL	nd	nd	nd
Pool 7	Fats, oils	119%	14.5	<MDL	14.5	<MDL	nd	49%	nd
Pool 8	Vegetables	98%	nd	<MDL	<MDL	<MDL	nd	nd	nd
Pool 9	Fruits	149%	1.5	0.49	0.90	0.14	55%	48%	47%
Pool 10	Potatoes	114%	1.1	<MDL	0.98	0.12	nd	51%	46%
Pool 11	Sugar, sweets	112%	6.8	<MDL	6.3	0.54	nd	50%	46%
Pool 12	Beverages	99%	nd	<MDL	<MDL	<MDL	nd	nd	nd

nd =not determined
for MDL levels, see Table 11.13:1

11.13.4 Exposure estimation

Using the data of CP concentration in food categories given in Table 11.13:2 and the per capita consumtion figures based on SBA statistics (Table 5:1), the per capita exposure of CPs is estimated. Using medium bound values, the exposure estimation is given in Table 11.13:3.

Table 11.13:3. Estimated per capita intake of CPs from food (ng/person/day), using data from Market Basket 2015 study. Intake is split into SCCPs, MCCPs and LCCPs, and is calculated by the medium bound method (nd=½MDL).

Food categories	**Per capita intake (ng/person/day)**				
	Sum CPs	(% of total)	SCCPs	MCCPs	LCCPs
Cereal prod.	256	5.6	126	126	4.6
Pastries	254	5.6	44	208	1.7
Meat	216	4.7	106	106	4.2
Fish	445	9.8	210	233	0.9
Dairy pr., fluids	660	14	323	323	13
Dairy pr., solids	166	3.6	80	83	3.2
Eggs	38	0.8	18	19	0.7
Fats and oils	784	17	128	652	4.9
Vegetables	116	2.5	56	57	2.0
Fruits	357	7.8	114	210	33
Potatoes	186	4.1	47	124	15
Sugar, sweets	917	20	57	792	68
Beverages	165	3.6	80	82	3.2
Total	*4560**	*100*	*1390*	*3016*	*154*
Total (ng/kg bw/day)	*60*	*1.3*	*18*	*39*	*2.0*

* The sum of intake of total CPs based on alternate methods on treating nd values: Lower bound (nd=0): 2660 ng/person/day; upper bound (nd=MDL): 6460 ng/person/day.

Using the medium bound method and the per capita method, the daily intake of CPs from food is estimated to 4.6 µg/person. Of this total CP intake, the major contributing food categories (based on MB values) are sugar/sweets, dairy products and fats/oil, and fish as the fourth most important group (ca 10% of total). However, as the contribution from the dairy group is entirely based on values below MDL, its importance could be questioned. Indeed, the importance of nd values for the total CP intake estimation could be shown by comparing the calculations based on LB (2660), MB (4560) and UB (6460 ng/person/day) calculations.

The analysed CPS are divided into SCCPs, MCCPs and LCCPs, and the intake calculation has been presented as these three major CP groups. Of the total intake (4.6 µg/person), SCCPs contribute by 30.5%, MCCPs by 66.1%, and LCCPs by only 3.4%.

The estimated total CP intake of 4,6 µg/person, or 60 ng/kg bw/day using the mean weight of 76.6 kg recommended earlier in this report, is lower than earlier calculations of CP exposure from food. In the study by Iino et al. (2005) the 50th percentile total daily intake of SCCPs for adult Japanese consumers was estimated to be roughly 100 ng/kg bw/day. As according to our study the SCCPs make up only ca 30% of the total CP

intake, the Japanese intake of total CPs would consequently be much higher, perhaps about 300 ng/kg bw/day. In the same study by Iino et al., the highest calculated SCCP intake (one year of age; 95th percentile) was 680 ng/kg bw/day. In another Asian study (Harada et al., 2011) the SCCP intake from food in China (Beijing), Japan (three areas) and South Korea (Seoul) was compared, based on two sampling time points. At the latest time point (2007-09), the mean intake of SCCPs in Beijing was 600 ng/kg bw/day (although based on few samples),whereas the Japanese SCCP intake was considerably lower, 55 ng/kg bw/day, and the Korean intake could not be estimated due to non-detectable SCCP levels.

Possible time trends. Whereas in the study by Harada et al. (2011) the calculated intake in Beijing had increased by two orders of magnitude from 1993 to 2009, no elevation of SCCP intake was seen during the same time period based on the Japanese samples. The large increase in time trend of CP exposure in China could be a consequence of the increase in large scale use of CPs in China (production about 1 million tons/yr in 2013; Glüge et al., 2016), which also could be seen in an environmental contamination and high CP levels in samples from wild life (e.g. Zhou et al., 2016). In Sweden no time trend on CP intake from food has been performed. In contrast to e.g. China, the Swedish use of CPs has been phased out and should at present be comparatively low. However, exposure to CPs in Sweden could take place e.g. by import of CP-containing products. In a study on CP levels in Swedish breast milk, SCCP and MCCP levels were followed in year-based pooled breast milk from 1996 to 2010 (Darnerud et al., 2012). The result showed a large between-year variation and no clear time trend could be seen. New analytical techniques may give improved possibilities to follow CP trends in food, and in breast milk.

11.13.5 Risk assessment

According to WHO (1996), a TDI for SCCPs of 100 µg/kg bw/day has been agreed on. The basis for this ADI is subchronic effects in rats (enzyme induction, thyroid hormone effects etc.) resulting in a NOAEL of 10 mg/kg bw/day. However, El-Sayed and Legler (2010) suggested a lower NOEL (1 mg/kg bw/day) based on body weight effects and condition of rat offspring (which would give a default TDI of 10 µg/kg bw/day). Also, an even lower TDI of 6 µg/kg bw/day has been reported by the Canadian Environment Protection Agency (CEPA, 2013).
If the lowest suggested TDI, 6 µg/kg bw/day, is applied in our study, the margin to our per capita intake figure of 60 ng/kg bw/day is a factor 100. This factor, although not great, may cover the body weight adjusted CP intake of high consumers and of difference body weight classes. However, by use of the higher TDI recommended by WHO, all Swedish consumers would likely have an CP intake well below this value.

11.13.6 Conclusion

The presented CP results is the first attempt to estimate intake of CPs from food for the Swedish consumer. The per capita intake, 4.6 µg/ person/day, is based on data on the CP groups SCCPs, MCCPs and LCCPs, in several case at or below the LOQ (MDL). The calculated Swedish per capita intake is suggested to be at the low end compared to Japanese data, and much lower than reported Chinese data. Choosing the lowest of several available TDIs the presented per capita intake is still lower by a factor of 100, which may be sufficient. Future analytical development and new toxicological data may improve quantification limits for low level analysis in analytical results and the accuracy in risk assessments.

11.14 3-MCPD and glycidol

11.14.1 Background

3-monochloropropane-1,2-diol (3-MCPD), 2-monochloropropane-1,3-diol (2-MCPD) and 2,3-epoxy-1-propanol (glycidol) are food processing contaminants. 3-MCPD and 2-MCPD are formed by heat, as a reaction product of lipids and chloride, in fat-containing foods. Depending of the type of food they may occur as free substances or in form of an ester with fatty acids. Glycidol, a very reactive compound, is rather associated with the formation and decomposition of 2- and 3-MCPD. The first time 3-MCPD and 2-MCPD were observed was in the late 1970s in the production of hydrolysed vegetable protein (HVP) which is used as a savory flavor-enhancing food ingredient (Velišek et al., 1978). Efforts to remove the use of hydrochloric acid and lowering the hydrolysis temperature in the production of HVP have led to a significant reduction of 3- and 2-MCPD. However, 3-MCPD is also found in other foodstuff such as smoked/cured fish and meat, in cereals when roasted at high temperatures and in baked goods (Baer et al., 2010). Esters of 3- and 2-MCPD and glycidol (glycidyl ester, GE) are mainly formed during the refining process of vegetable oils (Svejkovská et al., 2004). Highest levels of MCPD-esters and GE are found in palm oil (Hrnčiřík and Ermacora, 2010).

IARC has classified 3-MCPD as probably carcinogenic to humans, group 2B (IARC, 2013) and glycidol as a probable human carcinogen, group 2A (IARC, 2000).

A maximum level for 3-MCPD of 20 µg/kg in HVP and soy sauce have been laid down in Commission regulation (EC) 1881/2006. The Scientific Committee on food (SCF) has initiated discussions to establish maximum levels for foods other than HVP and soy sauce in response to the recent EFSA risk assessment of 2-MCPD, 3-MCPD and glycidyl ester. EFSA concluded that children's exposure to 3-MCPD and glycidol via food, especially infants receiving formula only, is of concern (EFSA, 2016b).

11.14.2 Chemical analysis

MCPD can react with fatty acids and form different mono- and di-esters depending on the fatty acid composition of the product. Glycidol can only form monoesters. The great variety of 2- and 3-MCPD esters as well as glycidyl esters complicates the determination of these compounds. There are a few official methods for the analysis of these esters

which are based on two different approaches, direct and indirect analysis, published by the American Oil Chemists' Society (AOCS) in 2013. Direct methods determine the target individual MCPD- and glycidyl esters by LC/MS (AOCS Cd 28-10). Indirect methods determine free 2- and 3-MCPD and glycidol released from the ester bond. Indirect methods include several analytical steps, hydrolysis and derivatisation, prior to analysis by GC/MS (AOCS 29a-13, b-13 and c-13, Ermacora and Hrnčiřík, 2013; Kuhlmann, 2011, 2015). Analytical methods for the determination of free 2- and 3-MCPD were first developed for the analysis of HVP and soy sauce but nowadays the determination of the free 2- and 3-MCPD have been included in the indirect methods for the measurement of ester bound MCPD (Wenzl et al., 2015).

Homogenates from seven food groups (fish, meat, cured meat, pastries, cereals, potatoes and sweets) were pooled and analysed for 2-MCPD, 2-MCPD-ester, 3-MCPD, 3-MCPD-ester and glycidyl ester. The samples were analysed by SGS in Hamburg, in August of 2016. SGS is accredited according to DIN EN ISO/IEC 17025:2005. SGS have developed an adapted a new method (SGS "5-in-2" low LOQ) that is based on the AOCS Official Method Cd 29b-13 (Horst et al., 2015). This method has been developed to fulfill the requirements of EFSA with respect to reporting the amounts of 2-MCPD, 3-MCPD, 2-MCPD ester, 3-MCPD ester and glycidyl ester separately and to lower the LOQs (Commission recommendation (EU) 661/2014).
The method used is a validated GC/MS method that is based on a multi-step extraction process that separates the free and bound analytes within one analytical procedure. The method measurement uncertainties are matrix- and concentration dependent and actual RSDs for the different matrices are between 0.6% and 4.4% depending of the substance. The LOQ for the free 2- and 3-MCPD is 5 µg/kg on whole sample base and for the bound 2-MCPD, 3-MCPD and GE is 10 µg/kg on whole sample base.

11.14.3 Analytical results

In general, the levels of 3-MCPD, 2-MCPD, their respective esters and glycidyl ester are low in most of the samples analysed, often below LOQ. Eventual high concentrations in one product are diluted as each sample consists of several products. The analytical results are reported in Table 11.14:1. The concentrations are in good agreement with reported concentrations of similar food categories compiled by the EU.

Levels of 2-MCPD are below LOQ in all the samples analysed. Highest concentration of 3-MCPD were observed in pastries (30 µg/kg) followed by fish/fish products (10 µg/kg).

Levels of 2-MCPD ester were below LOQ in almost all the samples except for pastries (94 µg/kg) and sweets (21 µg/kg). 3-MCPD ester was the most frequent compound and was measured in pastries (217 µg/kg), sweets (44 µg/kg) and fish (25 µg/kg) as well as in cereals. Pastries and sweets were the only two samples were measurable levels of GE were reported.

Table 11.14:1. Levels of free 2- and 3-MCPD, glycidyl ester, 2- and 3-MCPD ester. Levels are reported in µg/kg whole weight base.

Sample	N	2-MCPD ester	3-MCPD ester	Glycidyl ester	2-MCPD	3-MCPD
Cereal prod.	1	<10	10	<10	6	<5
Pastries	1	94	217	61	<5	30
Sugar, sweets	1	21	44	13	<5	<5
Fish	1	<10	25	<10	<5	10
Meat	1	<10	<10	<10	<5	<5
Processed meats	1	<10	<10	<10	<5	<5
Potatoes	1	<10	<10	<10	<5	7

11.14.4 Exposure estimation

Table 11.14:2 presents the calculated intake of 3-MCPD and glycidol from food. Since both chemicals are compounds formed during heating, higher levels may be found after cooking. However, based on the mean concentrations in the six collected food samples in the MB study and the levels of consumption, the result showed a mean intake of about 26 and 8 µg/person and day for 3-MCPD and glycidol respectively. From the collected data, pastries is the food group contributing with the highest mean 3-MCPD concentration and also highest intake. A probable conclusion is that there is a high proportion of heated fat in pastries.

Table 11.14:2. Estimated per capita exposure to 3-MCPD and glycidol from different food groups, and the total exposure, from MB calculations based on seven food categories (mean wt. of 76.6 kg; MB values, combining free and ester forms)

Food group	consumption (g/person, day)	**3-MCPD** conc. (µg/kg)	Intake µg/person, day (µg/kg b.w., day)	**Glycidol** conc. (µg/kg)	Intake µg/person, day (µg/kg b.w., day)
Cereal products	229	16	3.6	5	1.1
Pastries	48	247	11.9	61	2.9
Meat	212	7	1.5	5	1.1
Fish	46	35	1.6	5	0.2
Potatoes	126	12	1.6	5	0.6
Sugar and sweets	126	47	5.9	13	1.6
Beverages	315				
Total:			**26 (0.35)**		**7.6 (0.10)**

11.14.5 Risk assessment

3-MCPD

From animal studies it is concluded that 3-MCPD is carcinogenic. It has also been demonstrated that it is preferentially the kidneys that are affected by high levels of 3-MCPD. The mechanism behind the carcinogenic effect is not clear, but the interpretation by EFSA is that 3-MCPD is not a genotoxic compound *in vivo* although several in vitro studies point to a genotoxic potency (EFSA, 2016b).
Based on the effect on the kidneys and the use of benchmark modulating, EFSA concluded that a BMDL10 at 0.08 mg/kg, b.w.is reasonable. Using a safety margin of a factor of 100 will thereby result in a TDI of 0.8 µg/kg, b.w. and day (EFSA, 2016b). However, the interpretation of different studies vary between risk estimators, in a recently publication by WHO/JECFA the BMDL10 is set to ten times higher, i.e. 0.8 mg/kg, b.w. With a safety margin of 200 the proposed TDI level is 4 µg/kg, b.w., day (JECFA, 2016).

Glycidol

Glycidol is carcinogenic in mice and rats (NTP, 1990) and is classified by IARC as probably carcinogenic to humans (group 2A) (IARC, 2000). Glycidol is genotoxic and thereby no TDI is suggested (Aasa et al., 2016; EFSA, 2016b). The proposed MOE for glycidol in food is high (based on the present per capita MB intake calculations); MOE which is based on T25 is about 100 000 (Benford et al., 2010). T25 is the dose which corresponds to an increased cancer level of 25 per cent in animals studies. For Glycidol, T25 is calculated to 10 mg/kg b.w., day.

11.14.6 Conclusion

Based on the mean intake of both 3-MCPD and glycidol calculated from the market basket study there is little cause for concern.

12. Comparative risk characterization

The NFA has developed a tool, called the "Risk Thermometer", by which health concerns associated with chemical exposures can be compared (NFA, 2015). The Risk Thermemeter was applied to all types of toxic compounds analysed in this market basket study, and a few essential mineral elements. The Risk Thermometer is based on the traditional principle for risk characterisation where the estimated human exposure to a compound in food is compared, in one way or another, to a reference level: i.e., a reference point (RP) or a health-based guidance value like the tolerable daily intake (TDI) (which is established by applying assessment factors to the RP). The RP or TDI is based on the critical health effect observed in the pivotal study, for example derived by the benchmark dose (BMD) approach (EFSA, 2005b, 2009d, 2017; U.S. EPA, 2005). The methodology in the Risk Thermometer is different compared to traditional chemical risk charaterization in that the severity of the critical health effect is also considered in a systematic manner, i.e. cancer is judged to be more serious than skin lesions, for example. The underlying risk characterisation measure in the Risk Thermometer is called the severity-adjusted margin of exposure (SAMOE):

$$SAMOE = \frac{RP}{AF_{BMR} \times AF \times SF \times E} \quad (1)$$

- RP (health-based reference point): A BMD, NOAEL (no observed adverse effect level) or a LOAEL (lowest observed adverse effect level). The BMD_{10} represents the standard in the Risk Thermometer, i.e. a reference point that corresponds to a 10 per cent increase in risk or effect.
- AF_{BMR}: Is used on a case by case basis if the RP is regarded to significantly diverge from the standard RP that corresponds to a 10% increase in risk or effect. As a standard AF_{BMR} is set to 1 or 3 in case a NOAEL or a LOAEL is used as the RP, respectively.
- AF (assessment factors): An AF = 100 is used as a default: a factor of 10 for extrapolation between animals and humans and a factor of 10 to account for differences in susceptibility within the human population. Each standard factor of 10 is divided in a toxickokinetic and toxicodynamic component, which can be modified based on chemical specific data or knowledge.
- SF (severity factor): SF describes the severity of the critical health effect. This parameter distinguishes the SAMOE from traditional risk charaterization. The value of the SF may be 10^0, $10^{0.5}$, 10^1, $10^{1.5}$, or 10^2. A health effect classification scheme has been developed as a basis for determining the value of SF (NFA, 2015, Table 3).
- E (exposure): Estimated per capita exposure expressed per kg bw and day (a body weight of 76.6 kg was used as a standard across all compounds).

The data used for this analysis are given in Annex IX.

The SAMOE value is classified in one of five risk classes. These risk classes describe different levels of health concern (Figure 12:1). Exposure that are categorised in risk classes 1 and 2 are not regarded to represent a health risk in a long-term perspective. Risk class 3, in the middle of the scale, is currently regarded to represent a grey zone. Exposure that are categorised in risk classes 4 and 5 may represent potential health risks or indicate exposures that are higher than desireable (this may also apply to risk class 3).

There is uncertainty with regard to all parameters that define SAMOE (RP, AF, AF_{BMR}, SF, and E; see SAMOE equation 1). This is taken into account so that a uncertainty interval for the SAMOE is also established, which depends on the uncertainties in the input parameters. The uncertainty in each input parameter is based on data if this is available, and otherwise semi-quantitative standards are used. In this analysis, data driven uncertainties are only available for some of the RPs used. Detailed information about all parts of the methodology upon which the Risk Thermometer is based can be found in the NFA's report number 8 (NFA, 2015).

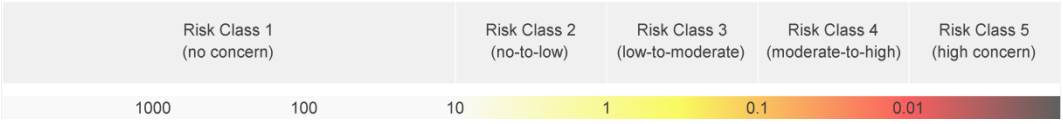


Figure 12:1. The SAMOE, here described on the logarithmic scale, is attached to a five graded risk classification scale describing different levels of health concern.

In Figure 12:2 it is illustrated that the SAMOE and the margin of exposure value (MOE: defined as the ratio between the RP and the exposure) is correlated. The slope of the regression line is close to 1 which indicates that that the overall value-based factor applied, i.e., the assessment factors (AFs) in combination with the severity factor (SF), does not systematically differ between compound that have a low and high SAMOE (low or high ranking). The use of AFs and the SF, which are part of the SAMOE but not the MOE, can be considered as an adjustment of the ranking for individual compounds depending on the type of data used as basis for risk charaterization.

Numerical results are given in Table 12:1. The point estimate of the SAMOE ranges between 0.14 and 10^7 across the 34 compounds investigated. Interestingly, all non-essential mineral elements, except for Ag, are together with dioxin-like compounds ranked the highest. For this group of compounds the estimated exposure is categorized in risk class 3, and regarded to be of low-to-moderate concern. For all remaining compounds (eighteen componds categorized in risk class 1, and ten compounds categorized in risk class 2) estimated exposures appear not be of concern (no or low concerns). It should be noted that this comparative assessment apply to a standard person (per capita exposure), and involves health concerns for the adult or its foetues (when the critical effect relate to the developing organism). The results may differ for specific sub-populations, and represents a screening that serves as one basis for risk-based prioritization with respect to chemical exposures at population/national level.

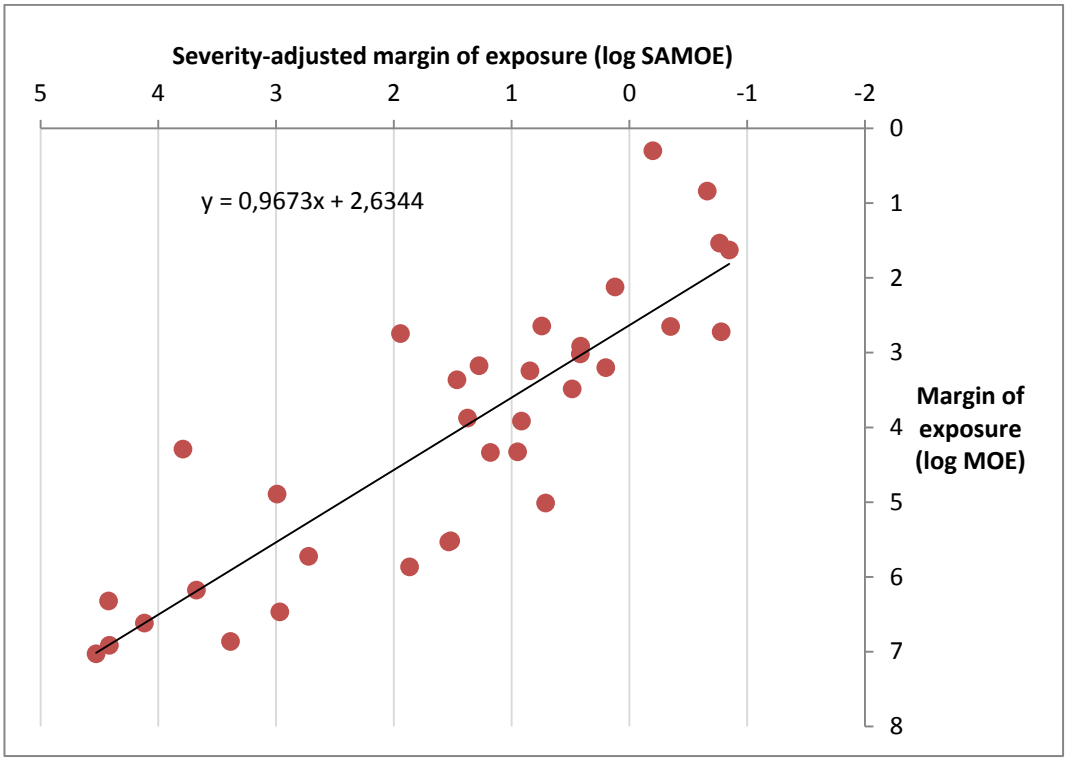


Figure 12:2. Correlation between the SAMOE and MOE

Table 12:1. Results from the Risk Thermometer

chemical	SAMOE	U95/L05[a]	Risk class	Uncertainty in classification[b]		MOE (RP/E)
				up	down	
dioxin	0.14	7.2	3	3	1	43
Al	0.17	10	3	2	1	530
Hg	0.17	5.8	3	2	1	34
Pb	0.22	3.5	3	1	1	6,9
Ni	0.45	18	3	1	2	450
Cd	0.63	4.6	3	1	2	2
iAs	1.3	8.2	2	3	1	130
3-MCPD	1.6	66	2	3	1	1600
deoxynivalenol	2.6	10	2	1	1	820
zearalenone	2.6	8.5	2	1	1	1040
T2 and H2	3.1	10	2	1	1	3100
glycidol	5.2	12	2	1	2	100000
BDE-99	5.5	6.8	2	1	2	440
I-PFOS	7.0	8.6	2	1	3	1800
fumonisins	8.3	9.0	2	1	3	8300
I-PFOA	8.9	10	2	1	3	21000
ochratoxin a	15	10	1	3	0	22000
BDE-153	19	4.9	1	1	0	1500
ndl-PCB	24	10	1	2	0	7500
BDE-47	29	4.6	1	1	0	2300
PAH4	33	13	1	1	0	330000
BaP	34	13	1	1	0	340000
HCB	74	10	1	1	0	740000
Cu	88	4.6	1	1	0	560
Cr III	530	10	1	1	0	530000
DDT	930	10	1	1	0	2900000
HBCD	982	4.9	1	1	0	78000
CP (sum)	2436	12	1	1	0	7300000
TCDPP	4743	10	1	1	0	1500000
Ag	6182	4.6	1	1	0	20000
TCEP	13126	10	1	1	0	4200000
TPHP	26042	10	1	1	0	8200000
BDE-209	26443	7.0	1	1	0	2100000
TCIPP	33731	10	1	1	0	1E+07

[a] Ratio between the upper 95th and lower 5th confidence bound of the SAMOE, based on a combination of data and sem-quantitative standards for model inputs (NFA, 2015).
[b] Uncertainty in the risk classification upwards and downwards: 1 (low), 2 (moderate), or 3 (high).

13. General discussion

The Market Basket 2015 study is the fourth Swedish market basket study conducted using a similar scheme. The present study has built on the experiences of earlier Swedish market basket investigations and has tried to develop the method but keeping the important functions to make the study results comparable over time. MB studies are similar to total diet studies (but the latter method analyse food treated as for consumption), and with both of these methods the population-based intake of various compounds are estimated. There is a limited number of market basket studies/TDS present in the scientific literature, probably because most of these studies have been published mostly in the grey literature. However, there are some examples of published European TDS (France, Ireland) and a discussion of TDS methods and a compilation of studies have been published (Moy and Vannoort, 2013). To promote and harmonise these studies within EU, a common EU project named TDS-Exposure has been in operation between 2012 to 2016, aiming at lifting the quality of these studies not least through production of instructions and guidelines, and further EU harmonization could be expected.

The per capita intake of nutrients and toxic compounds could be influenced both by the analysed levels in the food samples and by the per capita consumption data registered in the SBA food production and trade statistics. Therefore it is of importance that the consumption figures are correct, and that they indeed mirror the "real" consumption as far as possible. We have therefore compared per capita consumption data of the twelve food groups registered in MB 2010 with the mean consumption of the same food groups in the food consumption survey Riksmaten adults 2010-11. The comparison showed that the per capita MB data was consistently somewhat higher than the Riksmaten mean consumption data (unpublished results). One explanation to this general difference could be that the MB study data is based on food production/trade statistics, not taking into account the proportion of the food that is not eaten instead going to waste (see below, limitations).

Per capita consumption figures are the starting point in the estimation of per capita intake values for the different compounds, and the data from SBA has been the basis for our calculations from 1999 till the present study. In Chapter 10 the per capita consumption figures are presented, and changes over time (1999-2015) are indicated. For instance, the data suggest that meat, cereals, vegetables, fruit but also sugar and sweets consumption have increased from 1999, and that the mean consumption of dairy products and potatoes instead decreased during this time. If we study the overall consumption of food based on these per capita data, the amount of food consumed seems to have increased by 9%. Present results show that the energy intake from fat has increased from the previous MB study till now. Other nutritional results to be noted are a too high salt intake (although data not complete, table salt not included) and a marked decrease in iodine intake.

It is of importance to take the changes in per capita consumption into consideration when studying time trends in per capita intake, as both consumption changes and changes in food levels of nutrients and contaminants could influence the trend resuls. However, also other factors may have the possibility to influence per capita consumption figures over time.. For instance, it is possible that the food wastage part could have changed between

1999 and 2015, thus causing a under- or over-estimation of change in intake when using the MB approach. Moreover, the data quality used in the per capita consumption calculation has varied (further elaborated on in Chapter 10). In case of POP compounds such as chloropesticides, BFRs and PCBs, we show that fish is a major contributor for the total intake. The decreasing time trends of per capita intake of many of these compound is not a result of a decrease in fish consumption, as the fish consumption seems to have increased during this time period. Instead, if fish consumption would have remained unchanged, the decrease in per capita intake of these compounds should have been even more accentuated.

The per capita intakes described in this report are as far as possible compared to health-based reference values. These reference values have been taken from the scientific literature, and are often produced by international scientific organisations, e.g. EFSA or WHO. When several different reference values have been produced, we have tried to mention all these and show the resulting difference in margins between per capita intake and reference value. However, it should be kept in mind that exceeding of health-based reference value does not directly result in adverse health effects, but rather that the margin of safety will be smaller.

However, this report does not include in-depth risk or benefit assessments based critical assessment of the currently available scientific toxicological literature. There may be new toxicological data that has not been accounted for in the development of the health-based reference values used by us. It should also be noted that this report has estimated the per capita (population mean) intake from food, and high consumers or individuals with a different dietary pattern may have quite another, and sometimes higher, intake compared to the per capita intake. Also, the choice of a mean weight of 76.6 kg, the mean weight in the latest Swedish dietary survey on adults (Riksmaten vuxna 2010-11), could be questioned, as it is not representative for women, adolescents and children, who have lower average body weights. Another factor that have impact on the risk assessment is how the analytical data are treated. In this report we have, if not anything else is stated, chosen to extrapolate non-quantified levels in food with half the LOQ value (½LOQ=MB). Values below LOQ are especially important to deal with in an optimal way when it comes to time trend considerations (see below).

The MB per capita exposures are approximate Swedish population mean estimations that could be used a one tool in benefit or risk assessment of compounds present in food. However, the limitation with the MB method should be taken into consideration when using the data. Firstly, the per capita statistics refer to amounts available for consumption in the retail and catering sector. Food wastage occurs in shops and private households, which are not take into consideration in the MB study. It is estimated that 10-20% by weight of our total food purchase is not consumed maily because of food becoming inedible due to extended storage time or inappropriate storage conditions (NFA and Swedish EPA, 2015). Secondly, some food items or categories contain parts that will not be consumed, for instance bones, rind, peels, pips etc. This non-avoidable food wastage may not totally have been compensated for in our study by using a percentage reduction in the weight of certain food items, e.g. foods containing bone, such as pork chops, and chicken, whole fish, shellfish, many vegetables etc. (see Annex I). Thirdly, food produced and consumed locally will not be fully accounted for in the food statistics. For instance, private vegetable, potato and fruit production, berry- and mushroom picking, and private fishing and hunting could constitute a considerable part of the total food consumed by

certain sections of the population. Fourthly, it should be noted that food generally eaten more seldom is not part of the MB approach (covering ca. 90% of the total food amount for direct consumption). Fifthly, tap water for drinking, coffee, tea and alcoholic beverages are not included in the baskets and may have an impact on the total exposure estimates for some substances. Sixthly, for some compounds the migration from food packaging materials not monitored in our study (e.g. used within the fast-food sector) may be of importance to follow.

A comparative risk characterization was performed with the Risk Thermometer considering compounds across all groups (32 toxic compounds and two essential mineral elements), and represents a risk-based screening of chemical exposure at population/national level. Non-essential mineral elements and dioxin-like compounds were ranked the highest: risk class 3 (low-to-moderate concern). The exposures to remaining compound were regarded to be of no or low concern.

Some of the compounds studied in the present market basket study have been followed over the time and analyses of metals and POPs have been made since 1999 (however, no metal analyses in 2005). Thus, information on changes in per capita intake over time could be obtained and time trend results may be used in subsequent management decisions. One time trend example is the decreasing per capita intakes of POPs, such as chloropesticides, BFRs, PCDD/Fs and PCBs, seen already in the previous market basket study (MB 2010) and strengthened by the added 2015 time point. This observed decrease is in line with decreased POP levels in other studies, e.g. in Swedish breast milk (Lignell et al., 2015), and mirrors the restrictions and phasing-out of this compound group. A different time trend is seen on cadmium per capita intake, where an significant increase is observed from 1999 up to now (2005 not studied). In this case, increased cereal consumption, and especially consumption of whole-grain products known to contain higher Cd levels, may be one explanatory hypothesis. If so, the observed increase in per capita intake of cadmium is mainly an effect of changed consumption preferencies, and to a lesser extent changes in Cd levels in food. Final conclusions about the net health effects of such a change in consumption preferences cannot be drawn from the present study, since a comprehensive risk and benefit assessment has not been performed.

When time trends are based on market basket studies certain factors are important to consider. One important factor is the sensitivity of chemical analysis, as levels below LOQ and how to deal with these, may have a considerable impact on the final result. In this case, the ideal situation is that one high-quality laboratory has performed analyses of a specific nutrient or contaminant at all the different time points, with a good quality control showing that analytical performance have not changed between time points. Other important factors to consider are the sampling of food items and the sample treatment at the lab. These steps should also as far as possible follow a similar routine throughout the time span. In case of the mentioned POP and Cd time trends, the POP and non-essential metal analyses have been analysed at different labs but under quality accreditation. The PFAS analyses of samples between 1999 and 2015 were done by the same laboratory and the samples were analysed at random during the same time period in 2016.

Overall conclusions

Taking into account the estimated per capita intakes of studied compounds in relation to recommended intake levels (nutrients) or adverse health-based reference levels (toxic compounds), and including time trend data when such are available, some overall

conclusions could be made. Regarding the nutrient intake, a beneficial, decreasing trend on sodium and possibly also on added sugars was observed, although this study suggests that the estimated intakes of sodium and added sugar are still too high. The fat quality has improved, i.e.an increasing part consists of unsaturated fat. The per capita intakes of most minerals are in line with the Nordic Nutrition Recommendations (2012), but the exceptions are too low supplies of iodine and for women of childbearing age also iron. In case of iodine, the estimated intake has decreased markedly since the last MB study (2010). Furthermore, estimated intake of dietary fibre is lower than recommended (NNR, 2012).

Several potentially toxic, non-essential metals have estimated per capita intakes not very far from health-based tolerable intakes or other health-based reference points (RP). Among these are cadmium, inorganic arsenic, mercury and lead. In case of cadmium, the per capita intake is estimated to about half of the RP, which means that a certain part of the population (i.e. children, high consumers of cadmium-rich food items) will have an intake above this reference. In addition, MB data from 1999 and onwards show an increase in per capita cadmium intakes with time. The lead per capita intake is a little less than 20% of the RP (based on neurotoxic effects in children) - in this case no clear threshold for health effects is defined, but exposures below the RP are associated with a low risk. Among the organic contaminants, many compounds (e.g. PCB, chloropesticides, BFRs) show decreasing temporal trends and have per capita intakes sufficiently low compared to health-based reference points. A similar situation is seen for PFOS and PFOA, even if no decreasing time trend is seen for PFOA. However, the per capita intake of dioxin-like compounds are still near RP, especially if the new US EPA reference intake is used, and a certain part of the population will have an intake of dioxin-like compounds above this reference. The studied compound groups with carcinogenic potentials, PAHs and 3-MCPD/glycidol, have low per capita intakes that do not constitute any apparent health concern. Finally, it should be remembered that exceeding of RPs does not directly result in adverse health effects, but rather that the margin of safety will be smaller.

In an attempt to make the risk assessment of the studied toxic compounds more comparable, a standardized method for risk characterization was applied (the Risk Thermometer). Comparsion of compounds across all groups in the present MB study (32 toxic compounds and two essential mineral elements) was performed, representing a risk-based ranking of chemical exposures at population/national level. Non-essential mineral elements and dixoin-like compounds were ranked the highest: risk class 3 (low-to-moderate concern). The exposures to remaining compound were regarded to be of no or low concern. The results obtained with the Risk Thermometer are more or less in line with the conclusions based on separate assessment of compounds in this study using ordinary risk assessment methods. Finally, it should be stressed that certain population groups may have intakes that strongly diverge from the population mean, due to body weight-based differences and special dietary habits, which may place them in another risk class than that determined by the per capita intake in this report. Also, additional exposure not covered in the MB study (e.g. drinking water) may change the risk classification.

14. References

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15. List of annexes

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Annex I

MB 2015 shopping list

Provtagningslista för Matkorgen 2015

Livsmedelskonsumtion och näringsinnehåll. Uppgifter t.o.m. 2013 (JO 44 SM 1401)

http://www.jordbruksverket.se/webdav/files/SJV/Amnesomraden/Statistik,%20fakta/Livsmedel/JO44SM1401/JO44SM1401_ikortadrag.htm

Nr	grp	Livsmedel	Utvalt livsmedel	Kommentar	kg/L/år	Inköps-mängd	Prov-mängd, g	Avfall %	Invägd mängd	LNr	FS-faktor	Källa	Mult.-faktor invägn	*Anpassad* Invägd mängd*	*Tillagning* Prov mängd
1	1	Vetemjöl	Vetemjöl		7,8	1 pkt	78	0	78		0,7	SJV		195	78
3	1	Mjöl av blan	Rågsikt		0,2	1 pkt	2	0	2		0,7	SJV		5	2
4	1	Risgryn 1)	Risgryn, polerat		5,3	1 pkt	49	0	49		0,85	GfK		123	49
4	1	Risgryn 1)	Fullkornsris		5,3	1 pkt	4	0	4		0,85	GfK		9	4
5	1	Havregryn o	Havregryn		2,9	1 pkt	29	0	29		0,94	SJV		73	29
8	1	Vällingpulve	Vällingpulver, vuxen		0,6	1 pkt	6	0	6		0,956	SJV		15	6
9	1	Makaroner,	Pasta		8,7	1 pkt	87	0	87		0,7	SJV		218	87
10	1	Majsflingor,	Special K		3,0	1 pkt	3	0	3		0,86	GfK/ICA		8	3
10	1		Müsli	3 märken, varv 1 EMV	3,0	1pkt	16	0	16		0,86	GfK/ICA		40	16
10	1		Havrefras		3,0	1pkt	11	0	11		0,86			28	11
12	1	Knäckebröd	Rågknäcke		3,5	1 pkt	28	0	28		0,72	ICA		70	28
12	1		Frukostknäcke		3,5	1 pkt	7	0	7		0,72	ICA		18	7
14	1	Mjukt matbr	Franskbröd		51,6	1 bröd	206	0	206		0,86	/RM2010-11		516	206
14	1	Mjukt matbr	Rågsiktsbröd, limpa		51,6	1 bröd	206	0	206		0,86	/RM2010-11		516	206
14	1	Mjukt matbr	Grovt rågbröd, fullkornsb		51,6	1 bröd	103	0	103		0,72	/RM2010-11		258	103
	1 Totalt						836		836				**2,5**	**2090**	**836**
15	2	Kex, rån och	Småkakor, k	Ballerina, brago	4,1	2 pkt	21	0	21		0,95	ICA		194,75	
15	2	Kex, rån och	Småkakor, p	Pepparkakor	4,1	1 pkt	21	0	21		0,95	ICA		194,75	
16	2	Bullar, vetel	Vetebröd	vetelängd	4,8	1 längd	24	0	24		0,95	RM2010-11		228	
16	2	Bullar, vetel	Mjuk kaka	typ sockerkaka *dammsugare, arraksboll, mazarin*	4,8	3 st	24	0	24		0,95	RM2010-11		228	
17	2	Bakelser, tå	Konditoribita		8,8	3 st/sort	18	0	18		0,95	RM2010-11		167	
17	2	Bakelser, tå	Pizza, pirog	pizza (40%), pirog (40%)	8,8	7 st/sort	70	0	70		0,95	RM2010-11		669	
	2 Totalt						177		177				9,5	**1682**	
17	2U	Bakelser, tå	Pizza, pirog	pizza (40%), pirog (40%)	8,8		70	0	70		0,95	RM2010-11	**15,5**	**1091**	
22	3	Nötkött, färs	Lövbiff		12,5	>0,5 kg	6	0	6		0,953	GfK		19	6
22	3		Oxfilé		12,5		3	0	3		0,953	GfK		8	3
22	3		Entrecote		12,5		4	0	4		0,953	GfK		11	4
22	3		Nötfärs		12,5		66	0	66		0,953	GfK		199	66
22	3		Blandfärs (nöt+fläsk)		12,5		45	0	45		0,953	GfK		135	45
23	3	Griskött, färs	Ytterfilé		15,8	½ kg	43	0	43		0,953	GfK		128	43
23	3		Fläskfilé		15,8	½ kg	21	0	21		0,953	GfK		62	21
23	3		Karré/grishals		15,8	½ kg	43	***35***	28		0,953	GfK		83	28
23	3		Kotlett		15,8	½ kg	38	***20***	30		0,953	GfK		91	30
23	3		Fläskfärs		15,8	½ kg	14	0	14		0,953	GfK		43	14
24	3	Fårkött, färs	Lammkotlett/bog		1,2	300g	12	30	8		0,953	SJV		25	8
25	3	Fjäderfäkött	Hel Kyckling		18,7	1 st	22	***30***	16		0,945	GfK		47	16
25	3		Kycklingfilé		18,7	1 kg	125	0	125		0,945	GfK		376	125
25	3		Kycklingdetaljer med ben		18,7	1 kg	39	***42***	23		0,945	GfK		68	23
27	3	Kött av hare	Älgskav, fryst		1,9	1 pkt	19	0	19		0,953	SJV		57	19
30	3	Skinka, kass	Skinka, pålä	kokt, rökt	5,1	400g	28	0	28		0,953	GfK		83	28
30	3	Skinka, kass	Bacon	bacon, fläsk	5,1	1 st/sort	20	0	20		0,953	GfK		60	20
30	3		Kalkon		5,1	1 pkt	4	0	4		0,953	GfK		11	4
31	3	Korv, pastej	Falukorv		15,6	1st/sort	78	0	78		0,953	GfK		234	78
31	3	Korv, pastej	Varmkorv		15,6	1 pkt	30	0	30		0,953	GfK		89	30
31	3		Prinskorv		15,6	1 pkt	12	0	12		0,953	GfK		37	12
31	3	Korv, pastej	Leverpastej	bredbar	15,6	1 st/sort	17	0	17		0,953	GfK		51	17
31	3	Korv, pastej	Medvurst, rökt; salami	Varmkorv? häll bort	15,6	1 st/sort	19	0	19		0,953	GfK		56	19
32	3	Köttsoppor,	Köttkonserv	spad	1,1	1 burk	11	***40***	7		0,953	SJV		20	7
117-118	**3**		Ärter med fläsk, slang		*3,8*	1 förp	15	0	15			ICA		46	15
36	3	Djupfrysta k	Färsrätt, 1-p	typ köttbullar/pannbiff m potatismos	9,4	1 pkt	22	0	22		0,953	ICA/GfK		65	22
36	3	Djupfrysta k	Pastarätt, 1p	typ tortellini,	9,4	1 pkt	20	0	20		0,953	ICA/GfK		59	20
36	3		Pytt i panna		9,4	1 pkt	24	0	24		0,953	GfK		71	24
36	3	Djupfrysta k	Hamburgare		9,4	1 pkt	17	0	17		0,953	GfK		51	17
36	3		Köttbullar/Järpar		9,4	1 pkt	9	0	9		0,953	GfK		28	9
36	3	Djupfrysta k	Schnitzler/pressat fläskkö		9,4	1 pkt	4	0	4		0,953	GfK		11	4

Nr	grp	Livsmedel	Utvalt livsmedel	Kommentar	kg/L/år	Inköps-mängd	Prov-mängd, g	Avfall %	Invägd mängd	LNr	FS-faktor	Källa	Mult.-faktor invägn	*Anpassad* Invägd mängd*	*Tillagning* Prov mängd
	3 Totalt						828		774				3,0	**2322,4**	**774**
30	3U	Skinka, kass	Skinka, pålä	kokt, rökt	5,1		28	0	28		0,953	GfK		220	
30	3U	Skinka, kass	Bacon	bacon, fläsk	5,1		20	0	20		0,953	GfK		159	
30	3U		Kalkon		5,1		4	0	4		0,953	GfK		29	
31	3U	Korv, pasteji	Falukorv		15,6		78	0	78		0,953	GfK		624	
31	3U	Korv, pasteji	Varmkorv		15,6		30	0	30		0,953	GfK		237	
31	3U		Prinskorv		15,6		12	0	12		0,953	GfK		100	
31	3U	Korv, pasteji	Leverpastej	bredbar	15,6		17	0	17		0,953	GfK		137	
31	3U	Korv, pasteji	Medvurst, rökt; salami		15,6		19	0	19		0,953	GfK		150	
	3U Totalt						207						8,0	**1656,0**	
38/45-48	4	Flatfisk	Rödspätta	fryst om saknas	0,3	>0,5 kg	3	0	3		0,7	19,5		41	24
39/45-48	4	Torskfisk	Torsk	fryst om saknas	2,5	>0,5 kg	25	0	25		0,7			344	196
39/45-48	4	Alaska Pollo	Alaska Pollo	fryst om saknas	0,5	>0,5 kg	5	0	5		0,9	GfK/ICA		72	41
40/45-48	4	Sill/strömmir	Strömming	fryst om saknas	0,1	>0,5 kg	1	0	1		0,7	GfK/ICA		20	11
40/45-48	4	Sill/strömmir	Sill	fryst om saknas	0,1	>0,5 kg	1	10	1		0,9	GfK/ICA		18	10
41/45-48	4	Lax	Lax	fryst om saknas	4,1	0,7 kg	41	10	37		0,9	GfK/ICA		518	296
41/45-48	4	Pangasius	Pangasius	fryst om saknas	0,3	>0,5 kg	3	10	2		0,9	GfK/ICA		33	19
49-51	4		Rökt fisk, la	Varmrökt, enb skinn/ben/huvud tas bort	1,5	>0,5 kg	11	***20***	9			RM2010-11		126	72
49-51	4		Rökt fisk, la	Kallrökt (sida), enb skinn/ben tas bort	1,5	>0,5 kg	4	***20***	3			RM2010-11		42	24
52	4	Kaviar och a	Smörgåskaviar		1,2	1 tub	12	0	12		0,95	SJV		168	96
53	4	Sillkonserv	Inlagd sill	löksill el liknande	2,9	2 burk	29	50	15		0,9	SJV		203	116
54	4		Makrill, kons	i tomatsås	1,0	1 burk	5	0	5		0,9	GfK		70	40
54	4	Fiskkonserv	Tonfisk kons	olja/tomat	1,0	1 burk	5	0	5		0,95	GfK		70	40
55-56	4	Annan berec	Fiskbullar i	sås på burk	3,1	1 burk	16	0	16		0,95	SJV		217	124
55-56	4	Fiskfileer oc	Fiskpinnar, frysta		3,1	1 pkt	16	0	16		0,95	SJV		217	124
117-118	**4**		Fisksoppa		*3,8*	1 förp	8	0	8			ICA		106	61
58-59	4		Räkor (frysta + färska)		2,0	1 pkt	20	**72**	6		0,7	GfK		78	45
	4 Totalt						176		167				14	**2343**	**1339**
61	5A	Lättmjölk sa	Lättmjölk		16,1	1 L	161	0	161			SJV		483	
62	5A	Mellanmjölk	Mellanmjölk		46,8	2 L	468	0	468			SJV		1404	
63	5A	Standardmjö	Mjölk 3%		23,0	1 L	230	0	230			ICA		690	
64/66	5A	Lättfil m m, (	Lättfil		5,3	1 L	17	0	17			ICA		52	
64/66	5A		Lättyoghurt, naturell		5,3	1 L	17	0	17			ICA		52	
64/66	5A		Lättyoghurt med frukt		5,3	1 L	17	0	17			ICA		52	
67	5A		Mellanfil, 1,5% fett		5,8	1 L	29	0	29			ICA		87	
67	5A		Fruktyoghurt fett 1-2%		5,8	1 L	29	0	29			ICA		87	
65/68	5A	Filmjölk, 3,0	Fil 3%		21,1	1 L	84	0	84			ICA		253	
65/68	5A	Övriga sura	Fruktyoghurt fett >2%		21,1	1 L	42	0	42			ICA		127	
65/68	5A		Yoghurt, naturell 3%		21,1	1 L	84	0	84			ICA		253	
	5A totalt												3	**3541**	
70	5B	Tunn gräddc	Grädde 12%		1,9	3 dL	19	0	19			SJV		171	
71	5B	Gräddfil, 12	Gräddfil		1,4	5 dL	8	0	8			ICA		76	
71	5B		Matjoghurt 10%		1,4	5 dL	6	0	6			ICA		50	
72	5B	Tjock gräddc	Vispgrädde 40%		6,9	3 dL	69	0	69			SJV		621	
75	5B	Hårdost 3)	Hårdost 28%		12,2	0.5 kg	40	0	40			ICA		362	
75	5B		Hårdost 26%		12,2	0.5 kg	40	0	40			ICA		362	
75	5B		Hårdost 31%		12,2	0.5 kg	40	0	40			ICA		362	
76	5B	Smältost	Smältost 10%		1,0	1 pkt	10	0	10			SJV		90	
78	5B	Ost, andra s	Keso		5,7	500g	23	0	23			ICA		205	
78	5B		Färskost	typ Philadelphia	5,7	500g	11	0	11			ICA		103	
78	5B		Fetaost		5,7	1 pkt	23	0	23			ICA		205	
	5B Totalt						1470		1470				9	**2608**	
80	6	Ägg	Ägg		11,5	32 ägg	115	12	101			SJV		2125,2	
	6 Totalt						115		101				21	**2125,2**	
82	7		Smör	normalsaltat	2,1	500 g	21	0	21		0,945	SJV		252	
83	7		Margarin foli	Milda 80% + EVM	6,3	1 kg	16	0	16		0,956	GfK		197	
83	7		Margarin bo	Bregott	6,3	600 g	26	0	26		0,956	GfK		310	
83	7		Margarin bo	Flora	6,3	400 g	4	0	4		0,956	GfK		45	
83	7	Flytande ma	Flytande ma	Milda	6,3	500 g	10	0	10		0,956	GfK		121	
83	7		Margarin bo	Bregott mellan 57%	6,3	600 g	6	0	6		0,956	GfK		68	
83	7		Margarin bo	Flora	6,3	600 g	1	0	1		0,956	GfK		15	
83	7		Lättmargarir	Becel	4,9	750 g	15	0	15		0,956	GfK		176	
83	7		Lättmargarir	Lätta	4,9	750 g	34	0	34		0,956	GfK		412	
83	7		Majonnäs 8(	Majonnäs	1,1	1 + 1 burk	11	0	11		0,956	GfK		132	

Nr	grp	Livsmedel	Utvalt livsmedel	Kommentar	kg/L/år	Inköps-mängd	Prov-mängd, g	Avfall %	Invägd mängd	LNr	FS-faktor	Källa	Mult.-faktor invägn	*Anpassad* Invägd mängd*	*Tillagning* Prov mängd
83	7		Matolja	Matolja, raps	2	½-1 L	11	0	11		0,956	GfK		130	
83	7		Matolja	Matolja, oliv	2	½-1 L	5	0	5		0,956	GfK		58	
83	7		Matolja	Matolja, maj	2	½-1 L	4	0	4		0,956	GfK		53	
	7 Totalt						**164**		**164**				12	**1968**	
89	8	Morötter	Morötter		10,7	½ kg	107	***22***	**83**			SJV		250	
90	8	Övriga rotfru	Rödbetor		1,7	½ kg	17	***20***	**14**			SJV		41	
92	8	Gurkor	Gurka		6,2	1 st	62	0	**62**			SJV		186	
93	8	Lök	Gul lök		8,1	½ kg	81	***7***	**75**			SJV		226	
94	8	Purjolök	Purjolök		0,9	2 st	9	***8***	**8**			SJV		25	
95	8	Blomkål	Blomkål		1,4	1 st	14	***21***	**11**			SJV		33	
96	8	Vitkål, rödkå	Vitkål, färsk		4,8	1 st	17	***20***	**13**			RM2010-11		40	
96	*8*		Broccoli, färsk		*4,8*	*0,5 kg*	*31*	***20***	**25**			RM2010-11		75	
97	8	Sallat, sallac	Isbergssallat		6,1	1 st	61	***5***	**58**			SJV		174	
98	8	Tomater	Tomater		10,4	½ kg	104	0	**104**			SJV		312	
99	8	Övriga köks	Paprikor blandade		*9,1*	*3 st*	*91*	***15***	**77**					232	
101	8	Bönor, morö	Broccoli		*6,3*	*1 pkt*	18	0	**18**			GfK		53	
101	8	Bönor, morö	Wok-Grönsaker		*6,3*	*1 pkt*	15	0	**15**			GfK		45	
101	8		Ärter	*Gröns.bl (ärter, morötter, majs)*	*6,3*	*1 pkt*	13	0	**13**			GfK		40	
101	8		Övriga blanc		*6,3*	*1 pkt*	11	0	**11**			GfK		32	
101	8		Hackad spenat		*6,3*	*1 pkt*	*6*	*0*	**6**			GfK		19	
117-118	**8**		Tomatsoppa, typ Kelda		*3,8*	1 förp	15	0	**15**			ICA		46	
103	8	Köksväxter,	Ättiksgurkor		*3,2*	1 burk	32	***40***	**19**					58	
104	8	Köksväxter,	Ärter o morötter, konserv		12,1	1 burk	30	***40***	**18**					54	
104	8	Köksväxter,	Champinjoner, konserv		12,1	1 burk	30	***40***	**18**					54	
104	8	Köksväxter,	Gröna bönor, konserv		12,1	1 burk	12	***40***	**7**					22	
104	8	Köksväxter,	Tomater, konserv		12,1	1 burk	48	0	**48**					145	
	8 Totalt						825		**721**				3	**2162**	
106	9	Apelsiner, ci	Apelsiner		18,2	1 kg	182	***29***	**129**			SJV		388	
107	9	Vindruvor	Vindruvor		2,6	300g	26	***4***	**25**			SJV		75	
108	9	Mandel och	Blandade nö	Olika märken	2,6	1 påse	26	0	**26**			RM2010-11		78	
109	9	Äpplen och	Äpplen		13,7	1 kg	110	**8**	**101**			RM2010-11		302	
109	9	Äpplen och	Päron		13,7	300g	27	**8**	**25**			RM2010-11		76	
110	9	Körsbär, per	Persika/nektarin		3,1	3 st	23	**13**	**20**			RM2010-11		61	
110	9		Plommon		3,1	3 st	8	**13**	**7**			RM2010-11		20	
111	9	Bananer, m	Bananer		25,9	1 kg	220	**37**	**139**			RM2010-11		416	
111	9	Bananer, m	Meloner	Vatten, nät, galia	25,9	½-1 st	26	**48**	**13**			RM2010-11		40	
111	9	Bananer, m	Kiwi		25,9	3 st	13	**15**	**11**			RM2010-11		33	
112	9	Hallon, jordg	Jordgubbar, färska/frysta		2,8	200g	28	0	**28**			SJV		84	
113	9		Hallon, blåbär, frysta		1,3		13	0	**13**			SJV		39	
114	9	Russin, fikor	Russin		1,4	½ kg	14	0	**14**			SJV		42	
115	9	Frukter och	Persikohalvor, konserver		3,2	1 burk	32	0	**32**			SJV		96	
116	9		Lingonsylt		7,4	1 burk	37	0	**37**			ICA		111	
116	9		Jordgubbssylt		7,4	1 burk	15	0	**15**			ICA		44	
116	9	Sylter, marm	Äppelmos		7,4	1 burk	7	0	**7**			ICA		22	
116	9		Apelsinmarmelad		7,4	1 burk	15	0	**15**			ICA		44	
120	9	Saft av frukt	Apelsinjuice, konc		19,4	1 pkt	8	0	**8**			GfK		23	
120	9		Äppeljuice, konc		19,4	1 pkt	4	0	**4**			GfK		12	
120	9	Saft av frukt	Apelsinjuice, drickfärdig		19,4	1 L	78	0	**78**			GfK		233	
120	9		Äppeljuice, drickfärdig		19,4	1 L	31	0	**31**			GfK		93	
120	9		Måltidsdrick	3 sorter	19,4	1 fl	27	0	**27**			GfK		81	
120	9		Måltidsdrick	3 sorter	19,4	1 fl	16	0	**16**			GfK		47	
120	9		Blandsaft, konc, normalsö		19,4	1 fl	10	0	**10**			GfK		29	
120	9		Blandsaft, konc, lätt-/oso		19,4	1 fl	6	0	**6**			GfK		17	
120	9		Övriga dryck	Nektar?	19,4	1 fl	16	0	**16**			GfK		47	
	9 Totalt						1016		**851**				3	**2554**	
122	10	Potatis färsk	Potatis	u skal	45,2	2 kg	452	***22***	**353**		0,8	SJV		1410	705
125	10	Kylda och dj	Pommes frites, frysta		8,9	1 pkt	89	0	**89**		0,956	SJV		356	178
127	10	Andra bered	Chips		1,9	100g	19	0	**19**		0,956	SJV		76	38
	10 Totalt						560		**461**				4	**1842**	**921**
130	11	Strö-, farin-,	Strösocker		6,7	1 kg	67	0	**67**			SJV		268	
137	11	Kakaopulver	Drickchokla	typ O'boy, ICAHandlar nas	2,2	½ kg	22	0	**22**		0,95	SJV		88	
139	11		Honung		0,8	350 g	8	0	**8**			SJV		32	
140	11	Choklad och	Chokladpralı	t.ex. Aladin, Cloetta mfl	17,1	400g	87	0	**87**		0,95	GfK/ICA		349	
140	11	Choklad och	Sockerkonfektyr, typ lösg		17,1	300g	84	0	**84**			GfK/ICA		335	
141	11	Såser exkl n	Ketchup		14,2	½ kg	99	0	**99**			SJV		398	
141	11		Bearnaise/hollandaisesås		14,2		14	0	**14**			SJV		57	
141	11		Salladsdressing		14,2		14	0	**14**			SJV		57	
142	11	Glass inkl m	Glass 10% f	Vaniljglass, paket/tråg, fett ca. 10-11%	9,6	1 pkt	24	0	**24**			ICA		96	

Nr	grp	Livsmedel	Utvalt livsmedel	Kommentar	kg/L/år	Inköps-mängd	Prov-mängd, g	Avfall %	Invägd mängd	LNr	FS-faktor	Källa	Mult.-faktor invägn	*Anpassad* Invägd mängd*	*Tillagning* Prov mängd
142	11	Glass inkl m	Glasspinne/	Glass, styckesaker, typ strut, pinne, båt	9,6	1 st	24	0	**24**			ICA		96	
145	11	Kryddor inkl	Senap, kryddor m.m.		1,8	1 burk	15	0	**15**		0,956	SJV		61	
	11 Totalt						459		**459**				4	**1836**	
148	12	Läskedrycke	Läsk	*blandat, cola + 2 andra sorter*	*87,1*	*3 brk*	*697*	*0*	**697**			RM2010-11/ICA		1045	
148	12		Lightläsk	*lightvarianter*	*87,1*	*3 brk*	*174*	*0*	**174**			RM2010-11/ICA		261	
149	12	Mineralvatte	Mineralvatte	typ Vichy Noveau, Ramlösa el motsv, 1 av varje	10,7	2 brk	107	0	**107**			SJV		161	
151	12	Lättöl, lagrat	Lättöl	3 vanliga märken	3,0	3 brk	30	0	**30**			SJV		45	
152	12	Öl klass II (p	Öl 2,8%	3 vanliga märken	14,2	3 brk	71	0	**71**			SJV		107	
152	12	Öl klass II (p	Öl 3,5%	3 vanliga märken	14,2	3 brk	71	0	**71**			SJV		107	
	12 Totalt						1150		**1150**				1,5	**1725**	
	152														
							0		0						
	Totalt						8289		9382					**30651**	**3870**

Annex II

Cooking procedures, weights and yield factors

All food preparations according to instructions on packages

	Procedure	Water (g)	Weight raw (g)	Weight prepared (g)	Yield factor
Rice longgrain uncle bens	Boiled 20 min, water discarded	1000	138	388	2.81
Rice favorit	Boiled, boil until dry	312	166	377	2.27
Rice parboiled eldorado	Boiled, boil until dry	238	81	234	2.87
Rice parboiled garant	Boiled, boil until dry	237	123	247	2.00
Wholegrain rice	Boiled 11 min, water discharged	993	144	339	2.36
Wholegrain rice	Boiled 10 min, boil until dry	234	75	185	2.45
Wholegrain rice Frebaco	Boiled 11 min, boil until dry	196	76	165	2.18
Wholegrain rice Garant	Boiled 23 min, boil until dry	267	117	271	2.31
Oatflakes	Boiled, 4 min	455	94	521	5.53
Oatflakes	Boiled, 4 min	175	34	158	4.69
Oatflakes fortified w fiber	Boiled, 4 min	406	117	494	4.22
Gruel, adults	Heated	192	40	224	5.61
Havremust”	Heated	204	20	216	10.57
Pasta, barrilla	Boiled 10 min, water discarded	1947	123	257	2.09
Pasta, favorit	Boiled 11 min, water discarded	1960	93	192	2.06
Pasta, Garant	Boiled 13 min, water discarded	995	101	197	1.96
Pasta, Monte Castillo	Boiled 12 min, water discarded	988	100	218	2.17

	Procedure	Weight raw (g)	Weight prepared (g)	Yield factor
Plaice	Owenbaked	196	168	0.86
Plaice	Owenbaked	59	51	0.87
Cod	Owenbaked	295	265	0.90
Cod	Owenbaked	247	192	0.78
Pollock	Owenbaked to 55°C, 10 min	86	76	0.88
Pollock	Owenbaked to 55°C, 10 min	98	87	0.88
Baltic herring	Fried	139	108	0.77
Baltic herring	Fried	72	53	0.73
Herring, ’saltsill’	Fried	118	88	0.75
Herring, ’saltsill’	Fried	97	79	0.81
Salmon	Owenbaked	432	410	0.95
Salmon	Owenbaked	365	341	0.94
Striped catfish	Owenbaked	120	105	0.87
Striped catfish	Owenbaked	182	152	0.83
Fish fingers breaded (50% fish)	Fried, 6 min	233	225	0.97
Fish fingers breaded (50% fish)	Fried, 6 min	152	138	0.91

	Procedure	Weight raw (g)	Weight prepared (g)	Yield factor
Beef				
Lövbiff (5%)	Fried, 1 min, pantemp 166°C	38	28	0.72
Lövbiff (5%)	Fried, 1 min	66	56	0.84
Beef fillet (2%)	Fried, 5 min	164	147	0.89
Beef fillet (2%)	Fried, 8 min	110	93	0.84
Beef cube roll (3%)	Fried, 5 min	173	154	0.89
Beef cube roll (3%)	Fried, 5 min	148	119	0.80
Beef minced meat (53%)	Owenbaked at 200°C	266	239	0.90
Beef minced meat (53%)	Owenbaked at 200°C	148	124	0.84
Beef and pork minced meat (36%)	Owenbaked at 200°C	142	119	0.84
Beef and pork minced meat (36%)	Owenbaked at 200°C	251	222	0.89
Pork				
Pork loin (27%)	Owenbaked to innertemperature 65-	190	167	0.88

	Procedure	Weight raw (g)	Weight prepared (g)	Yield factor
	70°C			
Pork loin (27%)	Owenbaked to innertemperature 65-70°C	308	272	0.88
Pork fillet (13%)	Owenbaked to innertemperature 65-70°C	167	133	0.80
Pork fillet (13%)	Owenbaked to innertemperature 65-70°C	139	116	0.83
Pork collar (27%)	Owenbaked, 175°C	186	146	0.78
Pork collar (27%)	Owenbaked, 175°C	203	156	0.77
Pork chops (24%)	Fried, 6 min	161	142	0.88
Pork chops (24%)	Fried, 7 min	192	164	0.85
Pork minced meat (9%)	Fried, 7 min	229	176	0.77
Pork minced meat (9%)	Fried, 7 min	81	60	0.74
Lamb				
Lamb chops	Fried, 5 min	165	144	0.87
Lamb chops	Fried, 5 min	131	122	0.93
Chicken				
Chicken w bones (12%)	Owenbaked to innertemperature 75°C	221	206	0.93
Chicken breast fillet (67%)	Fried, pantemp 195°C	65	49	0.75
Chicken breast fillet (67%)	Fried, pantemp 195°C	223	163	0.73
Chicken breast fillet (67%)	Fried, pantemp 195°C	245	178	0.73
Chicken w bones (21%)	Owenbaked to innertemperature 75°C	526	439	0.83
Chicken w bones (21%)	Owenbaked to innertemperature 75°C	221	206	0.93
Game meat				
Moose meat thin slices	Fried	79	50	0.64
Moose meat thin slices	Fried	71	52	0.74
Meat products				

	Procedure	Weight raw (g)	Weight prepared (g)	Yield factor
Bacon (39%)	Fried, 8 min	64	26	0.41
Bacon (39%)	Fried, 8 min	98	53	0.54
Sausage ('Falu' sausage) (50%)	Owenbaked at 225°C	368	350	0.95
Sausage ('Falu' sausage) (50%)	Owenbaked at 225°C, 20 min	166	158	0.95
Sausage ('Falu' sausage) (50%)	Owenbaked at 225°C, 20 min	135	128	0.95
Hot dogs (19%)	Heated in water at 98°C, 5 min	101	100	1.00
Hot dogs (19%)	Heated in water at 98°C, 5 min	187	187	1.00
Miniature frankfurter('Prince' sausage) (8%)	Fried, 6 min	143	140	0.98
Miniature frankfurter('Prince' sausage) (8%)	Fried, 6 min, pantemp 193°C	130	125	0.96
Hamburgers (18%)	Fried, 6 min	180	153	0.85
Hamburgers (18%)	Fried, 6 min	115	98	0.85
Meatballs (10%)	Fried, 8 min	105	103	0.98
Meatballs (10%)	Fried, 8 min	92	89	0.97
Ready-to eat dishes				
Ready-to-eat dish w minced meat 1-p (23%),	Microvawe, 750 W, 5.5 min	417	403	0.97
Ready-to-eat dish w minced meat 1-p (23%),	Microvawe, 750 W, 5.5 min	413	389	0.94
Ready-to-eat dish w pasta 1p (21%) ‘pasta alfredo findus’	Microvawe, 750 W, 5.5 min	408	360	0.88
Ready-to-eat dish w pasta 1p (21%) ‘pasta alfredo findus’	Microvawe, 750 W, 5.5 min	433	406	0.94
Ready-to-eat ‘Swedish hash’ 1 p (25%)	Fried, 10 min	136	112	0.83
Ready-to-eat ‘Swedish hash’ 1 p (25%)	Fried, 6 min	239	200	0.84
Ready-to-eat pork schnitzel 1 p (4%)	Microvawe, 750 W, 6.5 min	426	392	0.92
Ready-to-eat pork schnitzel 1 p (4%)	Microvawe, 750 W, 6.5 min	429	348	0.81

	Procedure	Water (g)	Weight raw (g)	Weight prepared (g)	Yield factor
Potato, peeled, n=8	Boiled, 20 min	1500	719	725	1.01
Potato, peeled, n=8	Boiled, 20 min	1500	787	804	1.02
Pommes frites, ’favorit’	Owenbaked at 225°C, 16 min		418	282	0.67
Pommes frites, ’favorit’	Owenbaked at 225°C, 16 min		232	159	0.68
Pommes frites, ’felix’	Owenbaked at 225°C, 16 min		439	276	0.63

Annex III

Sample preparation of food categories

General sample preparation

For the homogenization of the final homogenates a household mixer (CutoMat, stainless steel bowl and knife) was used. This mixer was also used for individual samples of some food items unless something else is mentioned in the text below.
For the individual grinding of dry samples such as spaghetti, macaroni, rice, yellow peas, raisin and nuts, a Retsch ZM 100 mill with a stainless steel bowl and titan sieve was used.
All the cooked food were individually homogenised before mixing with the remaining uncooked ingredients.
The solid food samples are weighed in stainless steel containers and the liquid are weighed in glass containers.
All the glass containers were heated in + 400^0C after being rinsed with acetone.
All plastic containers used for metal analysis were washed with 10 % nitric acid.
All sample preparation was made in a laboratory with yellow light (sodium lamp) in order not to affect the amount of light sensitive vitamins in the samples.

Food groups

Group 1 Cereal products; flour, grain, cornflakes, pasta, bread.
Hard bread and cereals were, was due to the large volumes of sample, mixed together in two rounds, and then homogenized in a larger vessel.
The fresh bread were cut into halves and one half was mixed separately with a mixer before added to the homogenate sample.

Group 2 Pastries; biscuits, buns, cakes, pizza, pirogue, including Subgroup 2U with only pizza and pirogue
The fresh bakeries were mixed separately with a mixer directly after purchased.
To facilitate the homogenization of the frozen pizzas and pirogues, they were partly thawed.

Group 3 Meat; beef, pork, lamb, game, poultry, cured/processed meats, including Subgroup 3U with only cured/processed meats
All samples, even the cooked food, were mixed separately before an aliquot was taken to the homogenate except for hamburgers, liver pate, sausage, ham, salami, minced meat and meatballs.

Group 4 Fish; fresh, frozen, and canned fish, shellfish
The fish was, when possible, purchased as filleted. All residues of skin were removed before homogenizing, except for herring which is commonly eaten with the skin.

Every fish product was mixed separately before an aliquot was taken to the homogenate with the exception for tuna, smoked mackerel, caviar and fish balls which was cut into two pieces and taken directly to the homogenate.

Group 5 Dairy products; 5A Solids cheese (hard, processed, cottage), cream and sour cream and 5B Liquids milk, sour milk, yoghurt

The two subgroups are prepared and analyzed separately.
The homogenization of the solid group starts with the hard cheeses followed by the addition of the cottage cheese and sour cream to finally get a creamy homogenate.
The liquid group homogenate is prepared by first blending the different milks together separately, and also prepare a separate mixture of the different yogurts and sour milks. After that the two mixtures are homogenized together.

Group 6 Eggs; fresh eggs

The whole egg (white and yellow) was cracked directly into the mixer and to avoid extensive foaming the mixing time was kept short.

Group 7 Fats and oils; Butter, margarine, cooking oil, mayonnaise

The food items were without any further treatment weighed and added together for homogenization.

Group 8 Vegetables; fresh, frozen, and canned vegetables, root vegetables

The vegetables were washed and peeled as commonly prepared before eating.
Carrots and cucumber samples were added directly to the homogenate, while the rest of the vegetables were mixed separately before added to the homogenate.

Group 9 Fruits; fresh, frozen, and canned fruit products, juice, nuts, fruit-drinks, jam

The fruits were washed and peeled as commonly prepared before eating.
Bananas, apples and oranges are cut in halves, weighed and added to the homogenate.
Jams, juices and fruit-drinks are weighed and added to the homogenate

Group 10 Potatoes; fresh potato, French fries, potato crisps, potato purée (ready-made)

Fresh potatoes were peeled and cut into halves, and homogenized separately before added to the homogenate.
French fries and potato crisps were homogenized together before added to the homogenate.

Group 11 Sugar and Sweets; Sugar, honey, chocolate, sugar sweets, mustard, ketchup, dairy and vegetable fat-based ice-cream, ready-made sauces and dressings

To facilitate homogenization, the sweets were cut into small pieces and then frozen at -20^0C degrees. After that an extended time for homogenization was needed to get a reasonably homogeneous mixture.
Concerning the ice cream sticks, a representative part is selected and added to the homogenate.
The other food items are mixed directly in the homogenate without any other treatment.

Group 12 Beverages; soft drinks, mineral water, beer (up to 3.5 vol. % alcohol)

All beverages were weighed and mixed together to form the homogenate.

Annex IV

Fatty acids in the food samples (area percent)

	Cereal products	Pastries	Meat	Subgroup processed meats	Fish	Dairy products fluids	Dairy products solids
C4:0	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	0.3
C6:0	<0.1	<0.1	<0.1	<0.1	<0.1	1	0.7
C8:0	<0.1	0.4	<0.1	<0.1	<0.1	0.9	0.8
C10:0	<0.1	0.6	<0.1	<0.1	<0.1	2.6	2.7
C12:0	0.9	4.7	0.1	<0.1	<0.1	3.5	3.5
C14:0	0.7	3.4	1.6	1.5	2.8	11.7	11.8
C14:1	<0.1	<0.1	0.2	<0.1	<0.1	0.9	0.9
C15:0	<0.1	0.2	0.2	0.1	<0.1	1.1	1.2
C16:0	13.8	22.2	24	24.4	9.2	32.8	34
C16:1	<0.1	0.5	3.1	2.6	2.2	1.9	1.9
C17:0	<0.1	0.2	0.5	0.5	<0.1	0.7	0.7
C17:1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C18:0	2.6	6.7	12.7	13.5	2.3	12.1	11.8
C18:1	40.2	41.7	43.5	43	43.9	22.9	23
C18:1 cis-11	1.8	1.6	2.8	3	3	0.7	0.7
C18:2 cis-9	34.5	13	7.8	8.8	18.8	2.2	2.1
C18:2 cis-9 trans-11 CLA	<0.1	<0.1	0.2	<0.1	<0.1	0.6	0.6
C18:3	4.7	3.3	0.9	0.8	6.8	0.7	0.6
C18:4	<0.1	<0.1	<0.1	<0.1	0.9	<0.1	<0.1
C20:0	<0.1	0.4	0.2	0.2	0.3	0.2	0.2
C20:1	0.8	0.6	0.7	0.9	3.3	<0.1	<0.1
C20:2	<0.1	<0.1	0.3	0.4	0.8	<0.1	<0.1
C20:3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C20:3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C20:4	<0.1	<0.1	0.3	0.3	<0.1	<0.1	<0.1
C20:5	<0.1	<0.1	<0.1	<0.1	2.4	<0.1	<0.1
C22:0	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1
C22:1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C22:6	<0.1	<0.1	<0.1	<0.1	3.3	<0.1	<0.1
C24:1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SFA	17.9	38.9	39.4	40.1	14.6	67.4	67.6
MUFA	42.8	44.4	50.3	49.4	52.4	26.4	26.5
PUFA	39.2	16.3	9.4	10.3	33	3.4	3.3
Sum of n-6 FA	34.5	13	8.4	9.5	19.6	2.2	2.1
Sum of n-3 FA	4.7	3.3	0.9	0.8	13.4	0.7	0.6

Fatty acids below limit of quantification (0.1%) for all food groups are not presented in the table. CLA-conjugated linoleic acid; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; n-3 FA – n-3 fatty acids; n-6 FA – n-6 fatty acids.

Annex IV (contnd.). Fatty acids in the food samples (area percent)

	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and Sweets
C4:0	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
C6:0	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
C8:0	<0.1	0.3	<0.1	<0.1	<0.1	0.5
C10:0	<0.1	0.7	<0.1	<0.1	<0.1	0.6
C12:0	<0.1	2.6	0.8	<0.1	<0.1	4.5
C14:0	0.4	3.9	2.7	<0.1	<0.1	3.1
C14:1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1
C15:0	<0.1	0.3	<0.1	<0.1	<0.1	<0.1
C16:0	26.8	18.8	22.8	12.4	6.4	20.1
C16:1 cis	2.4	0.6	<0.1	0.5	<0.1	<0.1
C17:0	0.2	0.2	<0.1	<0.1	<0.1	<0.1
C17:1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C18:0	<0.1	5.1	3.6	3.1	2.8	17.3
C18:1	46.5	43.2	7.7	51.4	65.6	39.5
C18:1 cis-11	2.1	1.8	1.3	1.7	0.9	1.2
C18:2 cis-9	16	14.8	38.6	25	22.6	8.6
C18:2 cis-9 trans-11 CLA	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
C18:3	1.1	4.8	22.4	3.5	0.5	2.7
C18:4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C20:0	<0.1	0.4	<0.1	0.6	0.2	0.7
C20:1	0.3	0.7	<0.1	0.5	0.3	0.5
C20:2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C20:3	0.2	<0.1	<0.1	<0.1	<0.1	<0.1
C20:3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C20:4	2.1	<0.1	<0.1	<0.1	<0.1	<0.1
C20:5	<0.1	<0.1	<0.1	0.5	0.2	<0.1
C22:0	<0.1	0.3	<0.1	0.9	0.6	<0.1
C22:1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6
C22:6	1.5	<0.1	<0.1	<0.1	<0.1	<0.1
C24:1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
SFA	27.4	32.9	30	17	10	46.8
MUFA	51.3	46.7	8.9	54.1	66.8	41.8
PUFA	21.1	19.8	61	28.9	23.2	11.3
Sum of n-6 FA	18.4	14.8	38.6	25	22.6	8.6
Sum of n-3 FA	2.7	4.8	22.4	3.9	0.7	2.7

Fatty acids below limit of quantification (0.1%) for all food groups are not presented in the table. CLA-conjugated linoleic acid; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; n-3 FA – n-3 fatty acids; n-6 FA – n-6 fatty acids.

Annex V

Trans fatty acids in the food samples (area percent)

	Cereal products	Pastries	Meat	Subgroup processed meats	Fish	Dairy products fluids	Dairy products solids
C16:1 trans	<0.1	<0.1	0.1	<0.1	<0.1	0.4	0.4
C18:1 trans-9	<0.1	0.1	0.2	<0.1	<0.1	0.5	0.4
C18:1 trans-11	<0.1	0.2	0.5	0.2	<0.1	1.9	1.8
Sum of TFA	<0.1	0.4	0.8	0.2	<0.1	2.8	2.6

TFA-trans fatty acids

	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and Sweets
C16:1 trans	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C18:1 trans-9	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
C18:1 trans-11	0.2	0.4	<0.1	<0.1	<0.1	<0.1
Sum of TFA	0.2	0.6	<0.1	<0.1	<0.1	<0.1

TFA-trans fatty acids

Annex VI

Effect of cooking on fatty acids in meat and fish

	Meat raw (area %)	Meat cooked (area %)	Fish raw (area %)	Fish cooked (area %)
C4:0	<0.1	<0.1	<0.1	<0.1
C6:0	<0.1	<0.1	<0.1	<0.1
C8:0	<0.1	<0.1	<0.1	<0.1
C10:0	<0.1	<0.1	<0.1	<0.1
C12:0	0.1	0.1	<0.1	<0.1
C14:0	1.7	1.7	2.7	2.2
C14:1	0.2	0.2	<0.1	<0.1
C15:0	0.2	0.2	<0.1	0.2
C16:0	24.5	24.3	9.1	9.1
C16:1 cis	3.1	3	2.1	1.9
C16:1 trans	0.1	<0.1	<0.1	<0.1
C17:0	0.6	0.6	<0.1	0.2
C17:1	<0.1	0.4	<0.1	<0.1
C18:0	13.5	13.4	2.2	2.5
C18:1	42.6	41.7	45.3	45.9
C18:1 cis-11	0.2	0.2	<0.1	<0.1
C18:1 trans-9	0.4	0.4	<0.1	<0.1
C18:1 trans-11	2.6	2.6	3.1	3.2
C18:2 cis-9	7.7	8.3	18	16.4
C18:2 cis-9 trans-11 CLA	0.2	0.2	<0.1	<0.1
C18:3	0.9	0.9	7.1	6
C18:4	<0.1	<0.1	0.8	0.6
C20:0	0.2	0.2	<0.1	0.4
C20:1	0.7	0.7	3	3.5
C20:2	0.3	0.3	0.8	0.8
C20:3	<0.1	0.1	<0.1	0.2
C20:3	<0.1	<0.1	<0.1	0.3
C20:4	0.3	0.4	<0.1	0.2
C20:5	<0.1	<0.1	2.4	2.1
C22:0	<0.1	<0.1	<0.1	0.2
C22:1	<0.1	<0.1	<0.1	0.4
C22:6	<0.1	<0.1	3.2	3.2
C24:1	<0.1	<0.1	<0.1	0.3
SFA	40.7	40.4	14	14.8
MUFA	49.2	48.7	53.6	55.2
PUFA	9.3	10.2	32.4	30
Sum of TFA	0.8	0.7	<0.1	<0.1
Sum of n-6 FA	8.3	9.1	18.8	17.6
Sum of n-3 FA	0.9	0.9	13.5	12.4

Fatty acids below limit of quantification (0.1%) for all food groups are not presented in the table. CLA-conjugated linoleic acid; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids; TFA-trans fatty acids; n-6 FA – n-6 fatty acids; n-3 FA – n-3 fatty acids.

Annex VII

Essential and non-essential elements in food samples

			Concentration, µg/kg											Concentration, mg/kg								
Group	**Sub-proup**	**Sample ID**	**iAs**	**As**	**Ag**	**Cd**	**Co**	**Cr**	**Hg**	**Mo**	**Ni**	**Pb**	**Se**	**Al**	**Cu**	**Fe**	**I**	**K**	**Mn**	**Na**	**P**	**Zn**
Cereal products		C:1	6.2	8.1	2.7	21.8	15.7	14	< 1.6	400	219	5.0	29	0.87	2.00	15.42	0.030	2791	11.77	3010	1678	13.26
Cereal products		CG:1	8.3	10.2	2.5	24.9	9.2	16	< 1.6	385	228	3.2	34	1.20	1.97	14.15	0.046	2421	10.57	2975	1841	12.40
Cereal products		I:1	8.8	10.9	2.0	24.5	10.2	15	< 1.6	377	124	4.3	47	1.24	1.98	15.58	0.025	2346	10.47	2619	1695	13.07
Cereal products		L:1	9.4	11.5	1.9	32.8	10.7	23	< 1.6	460	268	4.8	53	10.8	2.26	19.79	0.082	2821	10.27	2573	1663	14.54
Cereal products		W:1	11.4	12.0	3.0	23.6	8.5	14	< 1.6	421	121	6.7	29	1.23	1.88	14.52	0.071	2250	9.68	2950	1326	11.34
Cereal products	cooked	CG:1 cooked	4.4	6.4	2.4	19.2	6.3	15	< 1.6	240	134	3.5	44	0.97	1.57	10.96	0.038	1679	7.63	2334	1393	9.38
Cereal products	cooked	W:1 cooked	8.5	8.7	2.3	16.5	6.5	14	< 1.6	295	94	2.8	34	0.70	1.51	9.58	0.047	1519	6.75	2005	1133	7.66
Pasteries		C:2	n.m	5.2	3.7	16.8	12.5	50	< 1.6	152	150	3.9	43	1.72	1.39	10.46	0.028	1874	5.56	3547	1190	8.71
Pasteries		CG:2	n.m	2.5	1.6	16.3	12.0	98	< 1.6	151	134	6.1	42	1.09	1.09	11.03	0.035	1841	4.17	3919	1410	8.21
Pasteries		I:2	n.m	3.0	3.3	16.8	11.8	36	< 1.6	154	134	3.7	31	1.53	1.21	8.79	0.026	2010	4.46	3544	1174	7.59
Pasteries		L:2	n.m	1.8	5.2	11.6	8.6	56	< 1.6	157	108	3.0	28	1.15	1.07	9.34	0.024	1746	5.92	3735	1499	7.42
Pasteries		W:2	n.m	3.1	1.4	15.9	14.1	64	< 1.6	139	161	5.9	36	2.37	1.23	11.35	0.028	1973	4.39	3768	1371	7.98
Pasteries	Pirouges/ pizza	C:2U	n.m	4.9	1.4	14.4	6.5	44	< 1.6	137	46	4.1	47	3.26	1.40	9.39	0.030	2624	3.96	4183	1885	14.62
Pasteries	Pirouges/ pizza	CG:2U	n.m	3.6	1.4	14.2	8.5	24	< 1.6	128	45	2.8	32	0.86	0.99	7.60	0.036	2020	3.00	4988	1796	13.12
Pasteries	Pirouges/ pizza	I:2U	n.m	7.8	1.1	16.1	6.1	39	< 1.6	139	47	4.4	81	1.34	1.16	8.87	0.027	2486	3.66	5293	2471	17.16
Pasteries	Pirouges/ pizza	L:2U	n.m	2.7	1.4	11.0	12.1	35	< 1.6	169	94	4.1	52	2.15	1.28	9.74	0.042	2224	6.43	4509	1397	10.00
Pasteries	Pirouges/ pizza	W:2U	n.m	4.5	1.7	15.2	6.4	35	< 1.6	124	44	3.1	54	1.11	1.04	7.15	0.031	2246	3.55	4169	1570	11.82
Meat		C:3	n.m	< 1.4	0.9	3.4	< 2.6	22	< 1.6	70	13	1.5	82	0.43	0.686	12.08	< 0.023	3053	0.398	3808	1680	19.32

			Concentration, µg/kg											Concentration, mg/kg								
Group	**Sub-proup**	**Sample ID**	**iAs**	**As**	**Ag**	**Cd**	**Co**	**Cr**	**Hg**	**Mo**	**Ni**	**Pb**	**Se**	**Al**	**Cu**	**Fe**	**I**	**K**	**Mn**	**Na**	**P**	**Zn**
Meat		CG:3	n.m	3.1	< 0.8	2.4	< 2.6	49	< 1.6	33	13	2.3	71	0.76	0.829	14.70	< 0.023	3397	0.443	4041	2254	24.05
Meat		I:3	n.m	2.6	< 0.8	2.7	< 2.6	23	< 1.6	53	16	1.9	69	0.31	0.623	10.88	< 0.023	2994	0.318	3822	1668	18.32
Meat		L:3	n.m	2.5	< 0.8	2.1	< 2.6	27	< 1.6	45	9	1.5	88	0.37	0.595	10.45	0.036	2972	0.299	3687	1857	18.15
Meat		W:3	n.m	1.9	< 0.8	2.0	< 2.6	34	< 1.6	38	15	4.8	136	0.37	0.558	10.07	0.042	3207	0.303	3129	1523	16.75
Meat	cooked	CG:3 cooked	n.m	2.5	< 0.8	2.3	< 2.6	153	< 1.6	34	28	2.8	114	0.59	0.775	21.21	0.027	3570	0.468	3785	2159	23.21
Meat	cooked	W:3 cooked	n.m	2.4	0.8	2.2	< 2.6	34	< 1.6	47	15	3.2	128	0.49	0.744	13.03	0.051	3660	0.451	4327	2057	21.42
Meat	processed	C:3U	n.m	1.7	< 0.8	1.7	< 2.6	75	< 1.6	43	9	2.8	84	1.24	0.857	12.48	< 0.023	2171	0.343	8569	1586	14.38
Meat	processed	CG:3U	n.m	1.3	< 0.8	1.3	< 2.6	91	< 1.6	39	10	2.0	61	1.42	0.584	12.01	< 0.023	1797	0.551	9144	1347	12.23
Meat	processed	I:3U	n.m	1.6	< 0.8	1.2	< 2.6	84	< 1.6	38	< 7	1.5	68	0.51	0.594	12.38	< 0.023	2140	0.317	8460	1187	13.34
Meat	processed	L:3U	n.m	1.5	0.8	1.4	< 2.6	31	< 1.6	46	< 7	2.6	69	0.73	0.615	14.23	< 0.023	2357	0.377	8873	1448	14.15
Meat	processed	W:3U	n.m	1.4	< 0.8	2.0	< 2.6	94	< 1.6	45	< 7	2.8	69	0.44	0.624	12.10	< 0.023	2776	0.603	8580	1420	12.34
Fish		C:4	< 1.7	1193	3.0	5.2	3.9	12	30	11	< 7	1.3	162	0.19	0.450	3.03	0.409	2472	0.273	6164	1696	3.92
Fish		CG:4	2.8	1323	5.5	5.3	< 2.6	15	30	10	7	2.0	224	0.26	0.618	3.16	0.387	2651	0.350	5445	1701	5.05
Fish		I:4	1.9	859	3.7	5.3	< 2.6	8	23	11	10	1.2	204	0.22	0.487	3.09	0.374	2380	0.361	5241	1565	4.54
Fish		L:4	2.2	2013	2.1	3.4	< 2.6	13	41	10	< 7	1.3	193	0.23	0.409	2.81	0.448	2407	0.342	5082	1654	4.46
Fish		W:4	2.5	1028	1.5	4.4	2.7	23	23	15	21	1.9	195	0.53	0.444	3.25	0.682	2468	0.546	6278	1478	4.20
Fish cooked		CG:4 cooked	< 1.7	1328	5.1	5.2	2.7	19	39	13	11	3.8	211	0.61	0.562	3.50	0.375	2734	0.493	5590	1787	5.09
Fish cooked		W:4 cooked	3.0	934	2.5	4.3	3.1	18	30	14	13	3.1	195	0.35	0.510	3.42	0.665	2770	0.486	7035	1636	4.68
Dairy products	Solid	C:5B	n.m	4.8	< 0.8	< 0.2	< 2.6	7	< 1.6	81	< 7	1.9	81	1.10	0.280	0.97	0.118	946.5	0.127	3468	3538	19.34
Dairy products	Solid	CG:5B	n.m	16.8	< 0.8	0.5	< 2.6	7	< 1.6	68	< 7	10.6	71	0.42	0.286	0.80	0.089	976.7	0.113	3315	2925	16.03
Dairy products	Solid	I:5B	n.m	2.3	< 0.8	< 0.2	< 2.6	< 5	< 1.6	69	< 7	4.7	78	0.54	0.315	0.81	0.087	953.4	0.116	3636	3296	18.04
Dairy products	Solid	L:5B	n.m	1.5	< 0.8	0.4	< 2.6	10	< 1.6	90	< 7	2.4	80	0.23	0.280	1.01	0.106	974.6	0.160	4651	3192	19.32
Dairy products	Solid	W:5B	n.m	1.7	< 0.8	< 0.2	< 2.6	9	< 1.6	68	< 7	1.5	53	0.33	0.227	0.87	0.086	851.6	0.120	3481	2919	16.93
Dairy products	Liquid	C:5A	n.m	1.0	< 0.4	0.2	< 1.3	3.4	< 0.8	44	< 4	0.6	10	0.03	0.060	0.21	0.054	1751	0.062	353.5	980.9	3.60
Dairy products	Liquid	CG:5A	n.m	0.7	< 0.4	0.2	< 1.3	< 2.6	< 0.8	34	4	1.1	23	0.04	0.065	0.19	0.056	1694	0.063	361.8	1006	3.53
Dairy products	Liquid	I:5A	n.m	< 0.7	< 0.4	0.2	< 1.3	2.8	< 0.8	55	10	0.8	21	0.04	0.063	0.22	0.073	1644	0.078	343.0	983.3	3.60

			Concentration, µg/kg										Concentration, mg/kg								
Group	**Sub-proup**	**Sample ID**	**iAs**	**As**	**Ag**	**Cd**	**Co**	**Cr**	**Hg**	**Mo**	**Ni**	**Pb**	**Se**	**Al**	**Cu**	**Fe**	**I**	**K**	**Mn**	**Na**	**P**	**Zn**
Dairy products	Liquid	L:5A	n.m	< 0.7	< 0.4	0.2	< 1.3	< 2.6	< 0.8	54	< 4	5.3	24	0.04	0.081	0.22	0.090	1720	0.078	384.1	1031	3.68
Dairy products	Liquid	W:5A	n.m	< 0.7	< 0.4	0.2	< 1.3	3.7	< 0.8	42	< 4	1.0	24	0.04	0.075	0.22	0.062	1593	0.047	325.4	921	3.41
Egg		C:6	n.m	1.6	< 0.8	< 0.2	< 2.6	< 5	< 1.6	53	< 7	< 1.1	178	####	0.575	18.52	0.208	1524	0.573	1320	2004	12.52
Egg		CG:6	n.m	5.4	< 0.8	< 0.2	< 2.6	< 5	2.8	33	< 7	< 1.1	204	####	0.586	18.02	0.343	1457	0.458	1277	2046	11.49
Egg		I:6	n.m	< 1.4	< 0.8	< 0.2	< 2.6	< 5	< 1.6	64	< 7	< 1.1	269	0.1	0.589	19.22	0.313	1505	0.505	1323	1857	11.59
Egg		L:6	n.m	4.0	< 0.8	0.2	< 2.6	5.2	1.8	101	< 7	< 1.1	238	0.1	0.643	18.66	0.264	1409	0.508	1369	1945	12.89
Egg		W:6	n.m	2.6	< 0.8	< 0.2	< 2.6	< 5	< 1.6	49	< 7	2.0	202	0.1	0.631	19.54	0.260	1438	0.584	1293	1991	12.56
Fats		C:7	n.m	1.8	< 0.8	< 0.2	< 2.6	< 5	< 1.6	11	< 7	< 1.1	< 6	0.41	0.017	0.27	0.023	320.8	0.023	4069	95.1	0.30
Fats		CG:7	n.m	1.7	< 0.8	0.3	< 2.6	6	< 1.6	13	< 7	< 1.1	< 6	0.4	0.015	0.40	< 0.023	325.1	0.024	3935	102.8	0.35
Fats		I:7	n.m	2.6	< 0.8	0.3	< 2.6	11	< 1.6	13	< 7	< 1.1	16	0.5	0.020	0.40	< 0.023	300.9	0.028	4137	112.5	0.33
Fats		L:7	n.m	1.5	< 0.8	< 0.2	< 2.6	7	< 1.6	13	< 7	1.3	9	1.0	0.013	0.56	< 0.023	355.3	0.018	4047	112.7	0.35
Fats		W:7	n.m	4.1	< 0.8	0.3	< 2.6	7	< 1.6	15	< 7	3.6	< 6	0.6	0.075	0.52	0.024	387.4	0.033	4471	158.6	0.60
Vegetables		C:8	n.m	< 1.4	< 0.8	9.6	3.7	14	< 1.6	89	31	2.9	8	0.24	0.445	3.05	< 0.023	2344	1.18	411.9	319.3	1.97
Vegetables		CG:8	n.m	< 1.4	< 0.8	7.9	4.2	18	< 1.6	71	43	1.8	7	0.2	0.409	2.68	< 0.023	1786	1.26	522.4	276.6	1.85
Vegetables		I:8	n.m	< 1.4	< 0.8	8.7	6.4	16	< 1.6	89	48	9.6	6	0.4	0.467	2.75	0.032	1759	1.25	746.2	269.1	1.78
Vegetables		L:8	n.m	< 1.4	< 0.8	15.6	3.1	16	< 1.6	58	33	5.5	< 6	0.3	0.413	3.73	0.030	2123	1.68	412.3	288.7	1.99
Vegetables		W:8	n.m	3.9	< 0.8	9.5	5.5	16	< 1.6	73	37	2.4	< 6	0.2	0.490	3.15	0.067	2178	1.22	467.8	307.3	2.07
Fruits		C:9	1.6	1.9	< 0.8	1.6	2.8	14	< 1.6	46	75	3.8	8	0.62	0.735	2.34	0.045	2051	1.60	172.7	278.5	1.36
Fruits		CG:9	1.5	2.8	< 0.8	2.3	2.9	12	< 1.6	42	35	2.8	< 6	0.4	0.709	1.76	0.031	2237	2.33	198.7	259.8	1.63
Fruits		I:9	< 1.3	2.9	< 0.8	1.2	6.7	12	< 1.6	39	59	2.9	< 6	0.4	0.835	2.61	0.031	2241	3.36	107.8	267.2	1.37
Fruits		L:9	< 1.3	2.6	< 0.8	1.1	7.2	13	< 1.6	19	146	3.5	< 6	0.6	1.06	3.38	0.031	2182	3.66	27.3	286.9	1.68
Fruits		W:9	1.6	3.1	< 0.8	1.3	2.6	13	< 1.6	26	84	3.2	< 6	0.3	0.779	2.22	0.032	1932	2.41	96.8	244.0	1.28
Potatoes		C:10	n.m	< 1.4	< 0.8	30.5	6.4	9	< 1.6	38	36	1.2	10	0.11	0.91	3.13	< 0.023	4285	1.14	195.4	485.8	2.99
Potatoes		CG:10	n.m	2.1	0.9	15.9	4.1	11.9	< 1.6	92	22	< 1.1	< 6	0.3	0.9	4.6	< 0.023	4665	1.26	273.9	478.8	2.66
Potatoes		I:10	n.m	< 1.4	1.2	29.3	4.9	9	< 1.6	47	37	< 1.1	< 6	0.1	0.9	4.3	< 0.023	4160	1.17	300.6	591.2	2.60

			Concentration, µg/kg											Concentration, mg/kg								
Group	**Sub-proup**	**Sample ID**	**iAs**	**As**	**Ag**	**Cd**	**Co**	**Cr**	**Hg**	**Mo**	**Ni**	**Pb**	**Se**	**Al**	**Cu**	**Fe**	**I**	**K**	**Mn**	**Na**	**P**	**Zn**
Potatoes		L:10	n.m	< 1.4	1.5	23.9	7.5	10	< 1.6	45	118	1.4	7	0.2	1.1	4.3	0.025	4454	1.33	350.8	506.5	2.44
Potatoes		W:10	n.m	< 1.4	0.9	25.4	5.1	8	< 1.6	71	19	2.5	< 6	0.2	0.7	3.9	< 0.023	3988	1.20	218.4	489.5	2.22
Potatoes	cooked	CG:10 cooked	n.m	2.6	0.9	18.0	4.1	7.6	< 1.6	82	14	1.4	< 6	0.20	0.75	3.97	< 0.023	4120	1.31	308.4	513.7	2.56
Potatoes	cooked	W:10 cooked	n.m	< 1.4	0.9	24.3	5.3	9	< 1.6	64	23	4.0	< 6	0.22	0.69	4.08	< 0.023	3756	1.24	253.9	471.6	2.27
Sweets and sugar		C:11	3.2	4.2	0.7	9.8	38.7	97	< 1.6	54	337	5.4	25	2.61	1.66	13.95	0.029	2397	2.25	3056	741.7	3.83
Sweets and sugar		CG:11	4.0	7.2	0.5	11.8	38.0	95	< 1.6	53	350	6.9	28	2.7	1.9	13.2	0.029	2698	2.59	2531	769.1	4.33
Sweets and sugar		I:11	11.4	9.8	0.5	10.4	48.4	198	< 1.6	46	382	9.6	13	5.8	1.7	18.5	0.021	2540	2.49	2325	524.6	3.22
Sweets and sugar		L:11	1.6	4.0	0.4	11.8	45.4	151	< 1.6	54	393	16.4	48	3.3	2.0	14.6	0.029	2615	4.62	2672	774.1	4.30
Sweets and sugar		W:11	16.1	12.4	0.4	15.0	39.5	135	< 1.6	55	366	15.0	32	6.9	1.5	17.0	0.029	2546	2.30	2852	741.9	3.83
Beverages		C:12	n.m	0.7	< 0.4	< 0.1	< 1.3	4	< 0.8	1.8	< 4	< 0.6	< 3	0.05	0.03	0.04	< 0.012	103.5	0.015	33	59.3	< 0.025
Beverages		CG:12	n.m	< 0.7	< 0.4	< 0.1	< 1.3	5	< 0.8	2.0	< 4	1.9	< 3	0.1	0.0	0.0	< 0.012	99.0	0.012	45.0	85.1	0.027
Beverages		I:12	n.m	0.8	< 0.4	< 0.1	< 1.3	3	< 0.8	2.2	< 4	5.0	< 3	0.1	0.1	0.0	< 0.012	89.5	0.013	39.3	73.9	0.025
Beverages		L:12	n.m	< 0.7	< 0.4	< 0.1	< 1.3	3	< 0.8	1.4	< 4	4.1	< 3	0.0	0.0	0.0	< 0.012	80.1	0.011	46.1	70.7	0.080
Beverages		W:12	n.m	0.8	< 0.4	< 0.1	< 1.3	4	< 0.8	1.2	< 4	< 0.6	< 3	0.1	0.1	0.1	< 0.012	101.4	0.015	32.6	50.9	< 0.025

Annex VIII

Phosphorous flame retardants in food samples

Total data set of PFR levels in Swedish market basket samples from 2015 (pg/g fresh wt.). Levels in yellow are beneath LOD, showing specific LOD levels for different food categories

No.	Sample cat.	TEHP	TNBP	TCEP	TBOEP	TPHP	EHDPHP	TDCIPP	TCIPP 1+2
1	Cereals	< 2150	< 3000	<500	<3000	673	4236	<500	2803
2	"	< 2150	<3000	<500	<3000	<500	<3000	<500	2100
3	"	< 2150	< 3000	<500	<3000	<500	9248	893	<400
4	"	< 2150	< 3000	<500	<3000	<500	1188	<500	470
5	"	< 2150	< 3000	<500	<3000	<500	4681	<500	589
6	Pastries	< 2150	< 3000	<500	<3000	1240	8443	<500	914
7	"	< 2150	< 3000	<500	<3000	<500	10057	<500	701
8	Meat	<800	<1000	< 200	<1000	<200	<1000	<200	<150
9	"	<800	<1000	< 200	<1000	<200	<1000	<200	<150
10	"	<800	<1000	< 200	<1000	324	<1000	522	<150
11	"	<800	<1000	< 200	<1000	1539	1215	<200	<150
12	"	<800	<1000	< 200	<1000	228	<1000	<200	<150
13	Fish	<800	<1000	< 200	<1000	<200	<1000	<200	<150
14	"	<800	<1000	< 200	<1000	434	1700	1051	<150
15	"	<800	<1000	< 200	<1000	950	5802	<200	<150
16	"	<800	<1000	< 200	<1000	1561	2552	<200	<150
17	"	<800	<1000	< 200	<1000	<200	1753	<200	<150
18	Dairy, fluid*	<800	<1000	218	<1000	<200	<1000	500	<150
19	"	<600	<800	<100	<700	<100	<700	<100	<100
20	"	<800	<1000	192	<1000	<200	<1000	<200	<150
21	"	<600	<800	<100	<700	<100	<700	<100	<100
22	Dairy, solid	<1000	<1500	<300	<1500	<300	<2000	<300	<200
23	"	<1000	<1500	<300	<1500	<300	<2000	<300	<200
24	"	<1000	<1500	<300	<1500	<300	<2000	<300	<200
25	"	<1000	<1500	<300	<1500	<300	<2000	<300	<200
26	"	<1000	<1500	<300	<1500	<300	<2000	<300	<200
27	Eggs*	<800	<1000	<150	<700	<150	584	<150	<150
28	"	<600	<1000	<150	<700	<150	1263	173	153
29	"	<600	<1000	<150	<700	<150	901	<150	231
30	"	<800	<1000	< 200	<1000	<200	876	393	<150
31	Fats, oils*	< 5000	<8000	< 2000	<6000	1754	<6000	<2000	<1500
32	"	< 5000	<8000	< 2000	<6000	12370	6706	<2000	<1500
33	"	< 5000	<8000	< 2000	<6000	3489	7613	<2000	<1500
34	"	< 5000	<8000	< 2000	<6000	1356	<6000	<2000	<1500
35	Vegetables	<200	<300	316	<300	131	240	1061	333
36	"	<200	<300	445	<300	58	386	358	167
37	"	<200	466	356	<300	<50	288	211	316
38	"	<200	<300	506	<300	94	394	<50	<50
39	"	<200	<300	445	<300	<50	<200	177	70
40	Fruit	<800	<1000	<150	<700	<150	946	574	<150

No.	Sample cat.	TEHP	TNBP	TCEP	TBOEP	TPHP	EHDPHP	TDCIPP	TCIPP 1+2
41	"	<800	<1000	<150	<700	<150	<700	237	<150
42	"	<800	<1000	<150	<700	<150	<700	233	<150
43	"	<800	<1000	161	<700	<150	<700	<150	241
44	"	<800	<1000	<150	<700	<150	<700	339	<150
45	Potatoes	<800	<1000	255	<700	<150	<700	293	233
46	"	<800	1015	<150	<700	476	<700	204	<150
47	"	<800	<1000	<150	<700	<150	<700	177	176
48	"	<800	<1000	<150	<700	<150	<700	485	278
49	"	<800	<1000	<150	<700	215	<700	290	<150
50	Sugar, sweets	< 2150	< 3000	<450	<3000	<500	<3000	1228	<400
51	"	< 2150	<3000	<450	<3000	<500	5923	<500	<400
52	Beverages	< 2150	< 3000	<450	<3000	<500	<3000	1069	<400
53	"	< 2150	< 3000	<450	<3000	<500	<3000	642	<400
<LOQ/all		53-53	51-53	44-53	53-53	36-53	29-53	31-53	37-53
-"- in %		100	96	83	100	68	55	58	70

Annex IX.

Data used for comparative risk characterization

Compound: reference	unit	E[a]	Reference point (RP)[b]					Assessment factor (AFs)[c]			Severity factor[d] (SF)	Species	Critical effect
			point estimate	LB	UB	type	BMR	Inter-species	Intra-species	BMR			
Cu: EFSA (2006a)	mg	0.018	10	-	-	NOAEL	-	1	2	1	3,16	humans	absence of adverse effects on liver function
Cr III: EFSA (2014)	mg	0.54	286	-	-	NOAEL	-	10	10	1	10	rats	changes in reproductive organ weights, sperm parameters, or estrous cyclicity
iAs: FAO/WHO (2011a)	µg	0.034	4,5	3,0	-	BMD	0,005	1	10	0,1	100	humans	lung cancer
Ag: WHO (2003)	µg	0.020	391	-	-	NOAEL	-	1	1	1	3,16	humans	pigmentation of the eye; considered to be the first sign of generalized *argyria* [10 g during 70 years; 10/(365*70) = 391 µg]
Al: EFSA (2008a)	µg	19	10000	-	-	NOAEL	-	10	10	1	31,6	mice, offspring	effects on the developing nervous system, neurodevelopmental effects in offspring
Cd: EFSA (2009)	µg	0.18	0,36	-	-	BMD	0,05	1	1	1	3,16	humans	change in kidney marker
Hg (MeHg): EFSA (2012)	µg	0.035	0,6 (1,2/2)	-	-	BMD	0,05	1	3,16 (k)	1	31,6	humans	developmental neurotox, children
Ni: EFSA (2015)	µg	1.7	760	280	-	BMD	0,1	10	10	1	31,6	rats	incidence of litters with three or more post-implantation losses
Pb: EFSA (2010)	µg	0.097	0,67	0,63	-	BMD	0,1	1	1	1	31,6	humans	incidence of kidney disease , defined as a 50 % reduction in GFR, to below 60mL/1.73 m2 body surface/min

Ochratoxin A: EFSA (2006b)	ng	0.37	8000	-	-	LOAEL	-	6 (k) 2,51 (d)	10	3	3,16	pigs	early markers of renal toxicity (effects on renal enzymes)
Zearalenone: EFSA (2011a)	ng	10	10400	-	-	NOAEL	-	3,98 (k)	10	1	10	pigs	oestrogenic effects on uterus and vulva in immature gilts
Deoxynivalenol: FAO/WHO (2010)	ng	122	100000	-	-	NOAEL	-	10	10	1	3,16	mice	change in body weight
T-2 + HT-2: EFSA (2011b)	ng	4.9	15000	10300	24700	BMD	0,05	10	10	1	10	pigs	decrease in anti-horse globulin titre values (antibody response)
Fumonisins: FAO/WHO (2011b)	ng	20	*165000*	165000	-	BMD	0,1	10	10	1	10 (el 3,16)	mice	megalocytic hepatocytes in male mice
PAH4: EFSA (2008b)	ng	2.1	690000	340000	-	BMD	0,1	10	10	1	100	mice	total tumour-bearing animals
BaP EFSA (2008b)	ng	0.41	140000	70000	-	BMD	0,1	10	10	1	100	mice	total tumour-bearing animals
3-MCPD: EFSA (2016)	µg	0.34	540	77	-	BMD	0,1	10	10	1	10	rats	tubular hyperplasia
Glycidol: (EFSA 2016)	µg	0.099	10200	-	-	T25	0,25	10	10	2,5	100	rats	neoplastic effects
CP (sum): CEPA (1993)	µg	0.00078	5700	-	-	LOAEL	-	10	10	3	10	rats, offspring	decrease in body weight gain in pups by day 21 of lactation
I-PFOS EPA (2016a)	ng	0.29	510	-	-	NOAEL	-	2,51 (d)	10	1	10	rats	reduced pup weight
I-PFOA EPA (2016b)	ng	0.25	5300	-	-	LOAEL	-	2,51 (d)	10	3	31,6	mice	reduced ossification in mice offspring/accelerated onset of puberty male mice offspring
TCEP: Ali et al (2012)	µg	0.0053	22000	-	-	NOAEL	-	10	10	1	*3,16*[e]	rodents	unknown
TPHP: Ali et al (2012)	µg	0.0085	70000	-	-	NOAEL	-	10	10	1	*3,16*[e]	rodents	unknown
TDCIPP: WHO/IPCS (1998)	µg	0.010	15000	-	-	NOAEL	-	10	10	1	3,16	rodents	increase in relative liver weight

TCIPP: Ali et al (2012)	µg	0.0075	80000	-	-	NOAEL	-	10	10	1	*3,16*[e]	rodents	unknown
HCB: WHO/IPCS (1997)	ng	1.1	810000	-	-	BMD	0,05	10	10	1	100	rats	neoplastic liver effects
DDT: WHO/IPCS (2011)	ng	1.7	5000000	-	-	NOAEL	-	10	10	1	31,6	dogs	earlier puberty
Dioxin: EPA (2012)	pg	0.47	20	-	-	LOAEL	-	1	3,16 (d)	3	31,6	humans	decreased sperm count and motility in men exposed to TCDD as boys / increased TSH in neonates
non-dioxin like PCBs: EFSA (2005)	ng	4.0	30000	-	-	NOAEL	-	10	10	1	3,16	rats	liver and thyroid toxicity
BDE-47: EFSA (2011c)	ng	0.082	190	173	-	BMD	0,1	2,51 (d)	1	1	31,6	mice	locomotion
BDE-99: EFSA (2011c)	ng	0.018	7,93	4,33	-	BMD	0,1	2,51 (d)	1	1	31,6	mice	locomotion
BDE-153: EFSA (2011c)	ng	0.0082	12,3	9,53	-	BMD	0,1	2,51 (d)	1	1	31,6	mice	total activity
BDE-209: EFSA (2011c)	ng	0.044	92420	49098	-	BMD	0,1	2,51 (d)	1	1	31,6	mice	total activity
HBCD: EFSA (2011d)	ng	0.40	3121	2502	4009	BMD	0,1	2,51 (d)	1	1	31,6	mice	locomotion

[a] The per capita exposure, expressed per body weight and day (a standard body weight of 76.6 kg is used across all compounds).

[b] The RP represents a BMD, NOAEL, or LOAEL. The lower and upper confidence limit of the BMD (LB and UB) is presented when available, and the benchmark response (BMR) is also given in case of an RP in terms of the BMD.

[c] The overall AF is divided in three main parts; 1) inter-species difference in susceptibility, 2) intra-species difference in susceptibility, and 3) a factor that is applied on a case by case basis for adjusting the RP if the BMR diverges from the default value of 10% or if a LOAEL is used as the RP. A default factor of 10 is used for both inter- and intra-species differences, and each factor of 10 is comprised by a toxicokinetic (k) and toxicodynamic (d) component: AF_{inter} = 2.51 (k) × 2.98 (d), and AF_{intra} = 3.16 (k) × 3.16 (d). Depending on the test species and the available data, one or several of the default sub-factors may be eliminated or replaced by data driven factors.

[d] The SF depends on the critical effect, and may assume default values of 1, 3.16, 10, 31.6 or 100. SFs have been assigned using the health effect classification scheme developed in NFA (2015) as a basis.

[e] SFs of 3.16 have been applied for TCEP, TPHP, and TCPP (same as for TDCPP) since the critical effects are not clear from the reference used as a basis.

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