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Swedish Market Basket Study 2022

Per capita-based analyses of nutrients and toxic compounds in market baskets and assessment of benefit or risk

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Preface

This report presents results from the latest Swedish market basket study, the Market Basket 2022. The market basket studies are conducted on regular basis to provide updated concentrations of several compounds, both nutrients and potentially toxic substances, in food groups representative for the average Swedish food consumption. The Market Basket 2022 also gives an overview of the population mean intakes of these compounds in relation to health-based reference values. This provides a basis in the risk and benefit assessments at the Swedish Food Agency and in the agency´s work for healthier dietary habits and safe food.

The present report provides data on concentrations of numerous compounds in food groups, exposure estimations and time trend analyses. We believe that the report is of interest for risk assessors and risk managers working at agencies or institutions at national and regional levels but also at European level, such as European Food Safety Authority. Policy makers could also benefit the report in prioritization and decision making. The large data volumes are also believed to attract experts in the food sector and researchers at universities.

Numerous colleagues, both at the Swedish Food Agency and at other institutions, have made valuable contributions to this report (see Appendix 7). The following experts are specially acknowledged for reviewing the report: Per Ola Darnerud (PhD, toxicologist, Uppsala University), Karin Norström and Elisabeth Nyberg (both at the Swedish Environmental Protection Agency), Cecilia Axelsson, Hanna Eneroth, Emma Halldin Ankarberg, Marie-Louise Nilsson (all at the Division of Risk and Benefit Assessment, Swedish Food Agency), Ulrika Fridén (Division for Laboratory Investigation and Analysis, Swedish Food Agency).

The per capita intakes are estimated using the Swedish Board of Agriculture's food consumption statistics. Hence, these data are crucial for the estimations.

We would like to give special gratitude to the Swedish Environmental Protection Agency for their generous financial support of food collection, chemical analyses of potentially harmful compounds, and result reporting.

Livsmedelsverket

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1 Abbreviations

AF	Aflatoxin
AI	Adequate intake. The AI is expected to meet or exceed the needs of most individuals in a life-stage group. The AI has larger uncertainty than RI and can be used when an RI cannot be determined.
AR	Average requirement. The average daily nutrient intake level that is estimated to meet the requirements of half of the individuals in a particular life-stage group in the general population. AR is usually used to assess adequacy of nutrient intake of population groups.
BFR	Brominated flame retardant
BMD	Benchmark dose
BMDL	Lower confidence limit of the benchmark dose
bw	Body weight
CEN	European Committee for Standardization
CPs	Chlorinated paraffins
CV	Coefficient of variation
DDT	Dichlorodiphenyltrichloroethane
dl	Dioxin-like
DON	Deoxynivalenol
EFSA	European Food Safety Authority
EU	European Union
E%	Energy percentage
FA	Fatty acid
FAO	Food and Agriculture Organization
GC/ECD	Gas chromatography with dual electron capture detectors
GC-MS/MS	Gas-chromatography tandem mass spectrometry
HB	Hybrid bound. Non-detects are set to 0.5*LOQ with exception for when all three samples in one food group have concentrations below LOQ. In those cases, non-detects are set to 0.
HBCDD	Hexabromocyclododecane
HBGV	Health-based guidance values
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HC-ICP-MS	High Resolution Inductively Coupled Plasma Mass Spectrometry
HMWDF	High molecular weight dietary fibre
HPLC	High-performance liquid chromatography

HPV	Hydrolyzed vegetable protein
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
JECFA	Joint FAO/WHO Expert Committee on Food Additives
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
LB	Lower bound. Non-detects are set to 0.
LCCPs	Long-chain chlorinated paraffins
LC-MS/MS	Liquid chromatography– tandem mass spectrometry
LI	Lower intake level
LMWDF	Low molecular weight dietary fibre
LOD	Limit of detection
LOQ	Limit of quantification
MB	Medium bound. Non-detect are set to 0.5*LOQ or LOD.
MCCP	Medium-chain chlorinated paraffins
MOE	Margin of exposure
MOET	Combined (total) margin of exposure
MUFA	Monounsaturated fatty acid
nd	Not determined
NMR	Nuclear magnetic resonance spectroscopy
NNR	Nordic Nutrition Recommendations
NOAEL	No observed adverse effect level
OTA	Ochratoxin A
PAH	Polycyclic aromatic hydrocarbon
PBDE	Polybrominated diphenyl ether
PCA	Polychlorinated-n-alkanes/Chlorinated paraffins
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofuran
PFAS	Per- and polyfluoroalkyl substances
PFRs	Organophosphate flame retardants
POPs	Persistent organic pollutants
Provisional AR	Provisional average requirement. The average daily nutrient intake level that is suggested to meet the requirements of half of the individuals in a particular life-stage group. Is used when an AR cannot be determined and has larger uncertainty than AR. Is calculated by multiplying adequate intake by a factor of 0.8.
PUFA	Polyunsaturated fatty acid
PVC	Polyvinyl chloride

RI	Recommended intake. The average daily dietary nutrient intake level that is sufficient to meet the nutrient requirements of nearly all (usually 97.5%) individuals in a particular life-stage group in the general population.
RISE	Research institute of Sweden
RP	Reference point
SAMOE	Severity-adjusted margin of exposure
SBA	Swedish Board of Agriculture
SCCPs	Short-chain chlorinated paraffins
SCF	Scientific Committee on Food
SD	Standard deviation
SF	Severity factor
SFA	Saturated fatty acid
TDI	Tolerable daily intake
TDS	Total diet study
TFA	Trans fatty acid
TWI	Tolerable weekly intake
UB	Upper bound. Non-detects are set to LOQ or LOD.
UL	Upper level. The maximum level of total chronic daily intake of a nutrient (from all sources) which is not expected to pose a risk of adverse health effects to humans.
WHO	World Health Organization

2 Glossary

Food group	Group of food items that are homogenised into one sample in the market basket studies. 19 food groups are included in the Market Basket 2022 (e.g. cereal products, pastries, pizza/hand pie (subgroup), meat, processed meat (subgroup), lean fish, fatty fish, meat substitutes, lean dairy products, fatty dairy products, plant-based drinks, eggs, fats/oils, vegetables, fruits, potatoes, sugar/sweets, beverages, and coffee/tea).
Per capita consumption	The average food consumption in the population.
Per capita intake	The estimated average intake of a compound (both nutrients and potentially harmful substances).

3 Summary

The Swedish Food Agency regularly conducts so-called market basket studies. The purpose of these is to provide an overall picture of the amount of nutrients and the amount of potentially harmful substances the Swedish population is exposed to from the food.

The average amount of a substance that each person is exposed to from food is called per capita intake. In this report, we estimate per capita intake based on

- levels of nutrients or potentially harmful substances in different types of food
- how much of the different types of food each person consumes on average ("per capita consumption").

The studies also set per capita intakes against various reference values to detect possible health risks. Since the market basket studies are conducted regularly, we also look for trends over time.

The food that was analysed[1] was collected from regular grocery stores in the autumn of 2022. We analysed samples from each food group and estimated per capita intake of nutrients and potentially harmful substances based on the levels of such substances in each food group and per capita consumption of food within the food group. To estimate per capita consumption, we mainly used statistics from the Swedish Board of Agriculture from 2020. The results are compared with previous market basket studies from 1999, 2005, 2010 and 2015.

3.1 Results

The Market Basket 2022 shows that most of the analysed nutrients and potentially harmful substances had a per capita intake that does not indicate a health risk in the general population. However, intakes of saturated fat, salt and dioxins were too high relative to their reference values. Also, the intake of acrylamide indicated a concern for public health, despite the fact that the intake is underestimated. The combined intake of PFAS-4 accounted for about half of the total intake of PFAS, which suggests a need for health-based reference values for additional PFAS.

When comparing the risks associated with the different substances, intakes of salt, and dioxins were ranked highest. However, these substances show decreasing intake over time.

[1] The following food groups were analysed: cereal products, pastries, meat, lean fish, fatty fish, meat substitutes, lean dairy products, fatty dairy products, plant-based drinks, eggs, fats and oils, vegetables, fruits, potatoes, sugars and sweets, beverages, coffee and tea.

3.1.1 Fat, carbohydrates and protein

The distribution of energy intake between total fat, carbohydrates and protein was in consonance with the recommended values. The per capita intakes of saturated fat and free sugar were higher than recommended while monounsaturated and polyunsaturated fats were in line with recommendations. Intake of trans fat remained low.

3.1.2 Vitamins

Per capita intakes of vitamins A, E, K, thiamine and riboflavin were higher than the so-called average requirement[2], which indicates that the Swedish population generally gets enough of these vitamins. Vitamin D was also higher than the average requirement, but with a smaller margin, suggesting that most people get enough, but that there also are groups at risk of deficiency. Folate intake was below the average requirement, which indicates that the Swedish population generally does not get enough. However, other studies of folate show that few adults in Sweden have low plasma levels.

3.1.3 Minerals

Per capita intakes of most minerals were well above the average requirement[2], suggesting that most people are getting enough. However, selenium and iron had per capita intakes at or just above average requirement, which means that some population groups may be at risk of deficiency of these minerals. Per capita intake of sodium was too high, suggesting an intake level that increases the risk of chronic disease in the population. The per capita intake of phosphorus was high enough to be just below levels that may have negative health effects.

3.1.4 Metals

The estimated intakes of all the investigated unwanted metals and arsenic were below the health-based guidance values, which is the aim. However, the intakes of cadmium and inorganic arsenic were close. For these, much of the exposure comes from cereals. The per capita intake of inorganic arsenic was considerably closer to the health-based guidance values in this market basket than in previous market basket studies. This is mainly due a reduction of the health-based guidance value for inorganic arsenic, but also partly due to increased intake.

3.1.5 PCBs and dioxins

Fatty fish, fats/oils, fatty dairy products and meat contributed most to the total per capita intake of PCBs[3] and dioxins[4]. The highest levels were found in fatty fish. The estimated per

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[2] The average requirement is defined as the intake that is considered necessary to maintain an adequate nutritional balance, function and growth for half of the individuals in a certain group (based on sex, age, pregnancy, breastfeeding). The average requirement is used when evaluating diets at population level.

[3] PCB measured as CB 153, a marker for non-dioxin like PCBs.

[4] Dioxins are measured as total-TEQ, corresponding to the sum of toxic equivalents of dioxin-like PCBs and PCDD/F.

capita intakes of PCBs and dioxins have decreased over time, which is positive. Nevertheless, for dioxins, it is at or above the tolerable weekly intake calculated by the European Food Safety Authority (EFSA) indicating a possible health risk in the population in Sweden.

3.1.6 Organochlorine pesticides

Of the organochlorine pesticides, hexachlorobenzene (HCB) and p,p'-DDE (a degradation product of DDT) had the highest levels, with fatty fish, fatty dairy products and meat contributing most to the total per capita intakes of HCB and p,p'-DDE. The estimated intakes have decreased over time and are at levels that do not indicate any health risk for the general population.

3.1.7 Brominated flame retardants

The levels of brominated flame retardants, i.e. nine polybrominated diphenyl ethers (PBDE) and hexabromocyclododecane (HBCDD), were generally low. Fatty fish, meat, and fats and oils contributed most to per capita intakes of both PBDEs and HBCDDs. The intakes of several PBDEs and HBCDDs have decreased over time, and do not appear to pose a health problem in the general population.

3.1.8 Per- and polyfluoroalkyl substances (PFAS)

Measurable levels of PFAS were seen in lean and fatty fish as well as eggs, with the highest levels in lean fish. In the remaining food groups, the levels were below the limit of what can be measured. The estimated per capita intake of PFAS-4[5] was below EFSA's tolerable weekly intake. Per capita intakes of PFAS-4 and the sum of all measured PFAS show downward trends between 1999 and 2022. This shows that measures to reduce levels of PFAS are important for a reduction in the exposure from food. Exposure from drinking water is not included in the market basket study but the estimated PFAS intake indicates that exposure from food is not a major health concern in the population.

3.1.9 Chlorinated paraffins

The highest levels of chlorinated paraffins were observed in pastries and eggs, followed by meat substitutes and meat. Per capita intake was about 10 times higher compared to the 2015 study. This may be due to differences in the method of analysis but also to increasing levels in food. Intakes remain low in relation to health-based reference values and do not pose a health risk to the general population.

[5] PFAS-4 includes PFOS, PFOA, PFNA and PFHxS.

3.1.10 Organophosphate flame retardants

Fruits, fatty dairy products, pastries and meat contributed most to the per capita intake of organophosphate flame retardants. TCIPP accounted for most of the intake, followed by EHDPHP, TEHP and TCDIPP[6]. As intakes were low in relation to health-based reference values, they do not pose a health risk to the general population.

3.1.11 Plasticizers

Highest levels of plasticizers were seen in fatty dairy products, followed by meat substitutes, fats and oils, fatty fish and cereal products. Cereal products and fatty dairy products contributed most to the intake. As intakes were low in relation to health-based reference values, they do not pose a health risk to the general population.

3.1.12 Acrylamide

The highest levels of acrylamide were found in pastries, followed by the food group sugar and sweets. Potatoes were also among the foods with the highest levels but lower than expected due to the fact that no cooking was done before analysis. The same food groups, together with coffee and tea, contributed the most to per capita intake. Despite an underestimate of levels, exposure was high at population level and carries an increased risk of health effects.

3.1.13 Glycidol, 2-MCPD and 3-MCPD

The highest levels of glycidol, 2-MCPD and 3-MCPD[7] were observed in the food groups fats and oils and pastries. These food groups also contributed most to per capita intake. The estimated intakes at population level do not give any reason for concern about health effects.

3.1.14 Polycyclic aromatic hydrocarbons (PAHs)

The highest levels of benzo[a]pyrene and the sum of benzo[a]pyrene and three additional PAHs (PAH4) were found in the food group fats and oils. The largest contribution to per capita intake came from meat for benzo[a]pyrene and from coffee and tea for PAH4. For both benzo[a]pyrene and PAH4, vegetables and cereal products were also important sources of intake. The per capita intake was higher compared to previous market basket studies, but the risk of health effect is still small.

3.1.15 Mycotoxins

The estimated intakes of ergot alkaloids, DON, T-2/HT-2, fumonisins, Alternaria toxins or patulin indicate that they are not a health risk in the general population. For aflatoxins and

[6] TCIPP, Tris(chloro-2-propyl) phosphate; EHDPHP, 2-ethylhexyl diphenyl phosphate; TEHP, Tris(2-ethylhexyl) phosphate; TCDIPP, Tris(1,3-dichloro-2-propyl) phosphate.

[7] 2-MCPD, 2-monochloropropane-1,3-diol; 3-MCPD, 3-monochloropropane-1,2-diol.

ochratoxin A, the results indicate a possible health risk. However, intakes are uncertain as most levels were below the limit of quantification, levels were only investigated in two food groups and the presence in food is often variable and sporadic.

3.1.16 Fluoride

Drinking water, which is not included in the market basket study, is considered to contribute most to the intake of fluoride in Sweden. Our estimate shows that food (including coffee and tea) could contribute 15-43% of the fluoride intake. Per capita intake; with 2 litres of drinking water added, was below the average requirement, which indicates that fluoride intake in Sweden is generally too low from a dental health perspective.

4 Sammanfattning

Matkorgen 2022 - Per capita-baserade analyser av näringsämnen och toxiska ämnen i svenska matkorgar och bedömning av risk och nytta

Livsmedelsverket genomför regelbundet så kallade matkorgsundersökningar. Syftet med undersökningarna är att ge en övergripande bild över hur mycket näringsämnen och hur mycket ämnen som kan vara skadliga som den svenska befolkningen får i sig via maten.

Mängden av ett ämne som varje person får i sig i genomsnitt kallas per capita-intag. I denna rapport har vi uppskattat per capita-intaget utifrån

- hur mycket näringsämnen respektive ämnen som kan vara skadliga som finns i olika typer av livsmedel (halterna)
- hur mycket av de olika livsmedelsgrupperna som varje person konsumerar i genomsnitt (”per capita-konsumtion”).

I undersökningen jämför vi också per capita-intagen med olika typer av referensvärden för att kunna upptäcka eventuella hälsorisker. Eftersom dessa matkorgsundersökningar sker regelbundet kan vi studera trender över tid.

De livsmedel som analyserades[8] kom från vanliga matbutiker under hösten 2022. Vi analyserade prover för varje livsmedelsgrupp och uppskattade sedan per capita-intaget utifrån halterna av ämnena i respektive livsmedelsgrupp och per capita-konsumtionen av mat inom livsmedelsgruppen. För att beräkna per capita-konsumtionen har vi främst använt data från Jordbruksverkets direktkonsumtionsstatistik från 2020. Resultaten jämförs med tidigare matkorgsundersökningar från 1999, 2005, 2010 och 2015.

4.1 Resultat

Matkorgen 2022 visar att de flesta näringsämnen och ämnen som kan vara skadliga som vi analyserade hade ett per capita-intag som inte tyder på en hälsorisk i befolkningen. Intagen av mättat fett, salt och dioxiner var dock för höga jämfört med deras referensvärden. Även intaget av akrylamid tyder på att det kan vara en hälsorisk, trots att intaget är underskattat. Intaget av summan av PFAS-4 utgjorde ungefär hälften av intaget av alla PFAS, vilket indikerar att hälsobaserade referensvärden för fler PFAS bör tas fram.

[8] Följande livsmedelsgrupper ingår i analysen: spannmålsprodukter, bakverk, kött, mager fisk, fet fisk, vegetabiliska köttersättningsprodukter, magra mejeriprodukter, feta mejeriprodukter, växtbaserade drycker, ägg, fetter och oljor, grönsaker, frukter, potatis, socker och sötsaker, drycker samt kaffe och te.

I jämförelsen mellan riskerna med de olika ämnena rankades intagen av salt och dioxiner högst. För dessa ämnen sågs dock ett minskande intag över tid.

4.1.1 Fett, kolhydrater och protein

Fördelningen mellan energiintagen från totala mängder fett, kolhydrater och protein låg inom de rekommenderade värdena. Per capita-intagen av mättat fett och fritt socker var högre än rekommendationerna medan enkelomättat och fleromättat fett var i linje med dessa. Intaget av transfett var fortsatt lågt.

4.1.2 Vitaminer

Per capita-intagen för vitamin A, E, K, tiamin och riboflavin var högre än det så kallade genomsnittsbehovet[9], vilket tyder på att den svenska befolkningen generellt får i sig tillräckligt av dessa vitaminer. Vitamin D var också högre än genomsnittsbehovet, men med mindre marginal, vilket tyder på att de flesta får i sig tillräckligt, men att det också finns grupper som riskerar brist. Folat var under genomsnittsbehovet, vilket tyder på att den svenska befolkningen generellt inte får i sig tillräckligt. Andra studier på folat visar dock att få vuxna i Sverige har låga nivåer i plasma.

4.1.3 Mineraler

Per capita-intaget av de flesta mineraler låg långt över genomsnittsbehovet[9], vilket tyder på att de flesta får i sig tillräckligt. Selen och järn hade dock per capita-intag i nivå med eller strax över genomsnittsbehoven, vilket innebär att det kan finnas en risk för brist på dessa mineraler i vissa befolkningsgrupper. Natrium hade för högt per capita-intag, vilket tyder på ett intag som ger ökad risk för kronisk sjukdom i befolkningen. Fosfor hade så högt per capita-intag att det ligger strax under nivåer som kan ha negativa hälsoeffekter.

4.1.4 Metaller

Per capita-intaget av alla de oönskade metallerna och arsenik låg under de hälsobaserade riktvärdena, vilket är målet. För kadmium och oorganisk arsenik låg dock per capita-intaget nära riktvärdet. Största delen av det kadmium och oorganisk arsenik som finns i mat kommer från spannmål. För oorganisk arsenik var per capita-intaget mycket närmare riktvärdet i denna matkorgsundersökning än i tidigare matkorgsundersökningar. Det beror främst på att de hälsobaserade riktvärdena för oorganisk arsenik har sänkts, men också delvis på ökat intag.

[9] Genomsnittsbehovet, average requirement (AR), är det intag som är tillräckligt för att upprätthålla god näringsbalans, funktion och tillväxt för hälften av individerna i en viss grupp (utifrån kön, ålder, graviditet, amning). Genomsnittsbehovet används vid värdering av koster på befolkningsnivå.

4.1.5 PCB och dioxiner

Fet fisk, fetter/oljor, feta mejeriprodukter och kött bidrog mest till det totala per capita-intaget av PCB[10] och dioxiner[11]. De högsta halterna fanns i fet fisk. Det beräknade per capita-intaget av PCB och dioxiner minskar över tid, vilket är bra. För dioxiner ligger det ändå i nivå med eller över det tolerabla veckointaget som beräknats av Europeiska myndigheten för livsmedelssäkerhet (Efsa), vilket tyder på att det kan finnas en ökad risk för påverka på hälsan i allmänbefolkningen.

4.1.6 Klororganiska bekämpningsmedel

Av klororganiska pesticider sågs högst halter av hexaklorbensen (HCB) och p,p'-DDE (en nedbrytningsprodukt av DDT). Fet fisk, feta mejeriprodukter och kött bidrog mest till det totala per capita-intaget av HCB och p,p'-DDE. Det beräknade intaget minskar över tid och ligger på nivåer som inte tyder på någon hälsorisk för allmänbefolkningen i Sverige.

4.1.7 Bromerade flamskyddsmedel

Halterna av de bromerade flamskyddsmedel, det vill säga nio polybromerade difenyletrar (PBDE) och hexabromcyklododekan (HBCDD), var generellt låga. Fet fisk, kött samt fetter och oljor bidrog mest till per capita-intagen av både PBDE och HBCDD. Intaget av flera PBDE och HBCDD minskar över tid, och verkar inte utgöra något hälsoproblem i allmänbefolkningen i Sverige.

4.1.8 Per- och polyfluorerade alkylsubstanser (PFAS)

Mätbara halter av PFAS sågs i mager och fet fisk samt ägg, med högst halter i mager fisk. I resterande livsmedelsgrupper var halterna under gränsen för vad som kan mätas. Det uppskattade per capita-intaget av PFAS-4[12] ligger under Efsas tolerabla veckointag. Per capita-intaget av PFAS-4 och summan av alla mätta PFAS visar på nedåtgående trender mellan 1999 och 2022. Detta visar att åtgärder för att minska halterna av PFAS är viktiga för att minska exponeringen från mat. Exponering från dricksvatten ingår inte i matkorgsundersökningen men det uppskattade PFAS-intaget tyder på att exponering från mat inte är en större hälsorisk i populationen.

4.1.9 Klorparaffiner

Högst halter av klorparaffiner sågs i bakverk och ägg, följt av ersättningsprodukter för kött samt kött. Per capita-intaget var ungefär 10 gånger högre jämfört med undersökningen från 2015. Detta kan bero på skillnader i analysmetod men också ökande halter i mat. Intagen är

[10] PCB mäts som CB 153, som är en markör för icke dioxin-lika PCB:er.

[11] Dioxiner mäts som total-TEQ, som motsvarar summan av toxikologiska ekvivalenter av dioxin-lika PCB:er och PCDD/F.

[12] I PFAS-4 ingår PFOS, PFOA, PFNA och PFHxS.

fortfarande låga jämfört med hälsobaserade referenspunkter och innebär inte någon hälsorisk i allmänbefolkningen.

4.1.10 Fosforbaserade flamskyddsmedel

Frukt, feta mejeriprodukter, bakverk och kött bidrog mest till per capita-intaget av fosforbaserade flamskyddsmedel. TCIPP stod för den större delen av intaget, följt av EHDPHP, TEHP and TCDIPP[13]. Eftersom intagen var låga jämfört med hälsobaserade referenspunkter innebär de inte någon hälsorisk i allmänbefolkningen.

4.1.11 Mjukgörare

Högsta halter av mjukgörare sågs i feta mejeripodukter, följt av ersättningsprodukter för kött, fetter och oljor, fet fisk samt spannmålsprodukter. Spannmålsprodukter och feta mejeriprodukter bidrog mest till intaget. Eftersom intagen var låga jämfört med hälsobaserade referenspunkter innebär de inte någon hälsorisk i allmänbefolkningen.

4.1.12 Akrylamid

Högst halter av akrylamid hittades i bakverk följt av livsmedelsgruppen socker och sötsaker. Potatis hörde också till de livsmedel som hade högst halter men lägre än förväntat beroende på att ingen tillagning gjordes innan analys. Samma livsmedelsgrupper, tillsammans med kaffe och te bidrog mest till per capita-intaget. Trots en underskattning av halterna är exponeringen hög på befolkningsnivå och innebär en ökad risk för påverkan på hälsan.

4.1.13 Glycidol, 2-MCPD och 3-MCPD

Högst halter av glycidol, 2-MCPD och 3-MCPD[14] sågs i grupperna fetter och oljor samt bakverk. Dessa livsmedelsgrupper bidrog också mest till per capita-intaget. De uppskattade intagen hos befolkningen ger inget skäl för oro för hälsopåverkan.

4.1.14 Polycykliska aromatiska kolväten (PAH)

De högsta halterna av bens(a)pyren samt för summan av bens(a)pyren och tre ytterligare PAH:er (PAH4) fanns i livsmedelsgruppen fetter och oljor. Störst bidrag till per capita-intaget kom från kött för bens(a)pyren och från kaffe och te för PAH4. För både bens(a)pyren och PAH4 utgjorde även grönsaker och spannmål viktiga källor till intaget. Det per capita-intaget var högre jämfört med i tidigare matkorgsundersökningar men risken är ändå liten för hälsopåverkan.

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[13] TCIPP, Tris(klor-2-propyl)fosfat; EHDPHP, 2-etylhexyl difenyl fosfat; TEHP, Tris(2-etylhexyl)fosfat; TCDIPP, Tris(1,3-diklor-2-propyl)fosfat.

[14] 2-MCPD, 2-monoklorpropan-1,3-diol; 3-MCPD, 3-monoklorpropan-1,2-diol.

4.1.15 Mykotoxiner

De uppskattade intagen tyder på att de inte är någon hälsorisk i allmänbefolkningen för ergotalkaloider, DON, T-2/HT-2, fumonisiner, Alternaria-toxiner eller patulin. För aflatoxiner och ochratoxin A indikerar resultaten en möjlig hälsorisk. Intagen är dock osäkra då de flesta halterna låg under kvantifieringsgränsen, halter endast undersöktes i två livsmedelsgrupper och då förekomsten i livsmedel ofta är heterogen och sporadisk.

4.1.16 Fluorid

Dricksvatten anses bidra mest till intaget av fluorid i Sverige men ingår inte i matkorgsundersökningen. Vår uppskattning visar att mat (inklusive kaffe och te) skulle kunna bidra med 15–43 procent av fluoridintaget. Per capita-intaget tillsammans med 2 liter dricksvatten var under genomsnittsbehovet, vilket tyder på att fluoridintaget i Sverige generellt är för lågt ur ett tandhälsoperspektiv.

N.B. Rapporten är skriven på engelska. Endast titel och sammanfattning har översatts till svenska.

5 Background

The Swedish Food Agency regularly conducts market basket studies to obtain current concentrations of a broad range of compounds in food groups representative for the Swedish food consumption. Foods are bought in major grocery stores, homogenised into pooled samples of specific food groups, and used as basis for chemical analyses of contaminants, naturally occurring unwanted substances, and nutrients. The contents in the market baskets are primarily based on statistics from the Swedish Board of Agriculture (SBA) (Swedish Board of Agriculture, 2021b), but also data from Swedish Food Agency´s dietary surveys (Riksmaten) (Amcoff et al., 2012, Warensjö Lemming et al., 2018a), household-consumption statistics and sales statistics. Hence, per capita consumption is estimated as a measure of mean consumption per person in the entire Swedish population. By combining the per capita consumption with concentrations of compounds in the food groups, the market basket studies give quantitative estimations of the average exposure of the compounds in the Swedish population (i.e. per capita intake estimations). This enables comparisons of per capita intakes of nutrients with nutrition recommendations, and, for potentially harmful substances, comparisons with health-based reference values. Because the market basket studies are conducted regularly, it is also possible to investigate time trends of per capita intake of those compounds. Previous market basket studies at the Swedish Food Agency are from 1999 (Darnerud et al., 2006, Becker et al., 2011), 2005 (Tornkvist et al., 2011, Becker et al., 2008), 2010 (Swedish Food Agency, 2012), and 2015 (Swedish Food Agency, 2017).

The market basket studies provide data on concentrations of compounds in food groups, exposure estimations and time trend analyses important for risk- and/or benefit assessments conducted at the Swedish Food Agency, but also at the European Food Safety Authority (EFSA). One advantage of market basket studies is that they provide analytical data and intake estimations for many compounds in a cost-effective way. Another advantage is that it is not based on self-reported data. The studies are limited by that the information is an average for the entire Swedish population and no individual data or distributions are given. By combining data from the market basket studies with food consumption data from dietary surveys (e.g. Riksmaten surveys) or biomonitoring data, an overall picture of time trends and exposure among certain population groups or high consumers can be assessed. The dietary surveys Riksmaten collect detailed consumption data on individual level by asking participants to register everything they eat or drink during specific reporting days (Amcoff et al., 2012, Warensjö Lemming et al., 2018a).

The market basket study resembles a so-called total diet study (TDS). However, the foods are analysed as *consumed* (i.e. cooked if appropriate) in a TDS, whereas the foods are analysed as *purchased* in the market basket study. Inedible parts such as peel, shell, bones, broth etc. are removed in market basket studies. Also, the market basket study uses average population consumption data and not individual food consumption data from dietary surveys, as recommended by the TDS guidelines (World Health Organization et al., 2011). Even if the market basket study not completely fulfils the criteria for a TDS, it has been conducted in agreement with the guidance of a harmonised total diet study approach produced by EFSA, Food and Agriculture Organization of the United Nations (FAO), and World Health Organization (WHO) (World Health Organization et al., 2011) as much as possible. TDS are performed in several countries, such as Germany (Sarvan et al., 2021, Stadion et al., 2022), France (ANSES, 2011), Portugal (Vasco et al., 2021), Italy (Cubadda et al., 2020), US (Gavelek et al., 2020), and Canada (Cao et al., 2019).

6 Aims

The main aims of the Market Basket 2022 are:

- To obtain data on concentrations of contaminants, naturally occurring unwanted substances and nutrients in food groups representative for the average Swedish food consumption.
- To estimate per capita intakes of analysed compounds in order to evaluate adherence to nutrition recommendations and possible risks of adverse health effects due to toxic compounds.
- To investigate contribution of major food groups to the total intake of analysed compounds.
- To evaluate time trends of intake for those compounds analysed in both the current and previous market basket studies.

7 Methods

7.1 Food groups and the per capita concept

7.1.1 Consumption data

Food consumption data in the market basket study was defined as per capita consumption, i.e. the total weight of food sold annually in Sweden divided by the number of inhabitants in Sweden. The consumption data for the majority of the food groups in the Market Basket 2022 were based on statistics from the SBA (Swedish Board of Agriculture, 2021b). Briefly, the statistics were based on the amount of food produced in Sweden, adjusted for export and import data, and minus a template of food waste in the industry. Household food waste was not considered in the statistics of the SBA. Per capita consumption data in the Market Basket 2022 were based on preliminary data from 2020 (see Table 1). For some food groups, there were no data (meat substitutes and plant-based drinks) or only old data (fish) available from the SBA. The consumption of these food groups was therefore estimated using other data sources. Fish consumption was based on seafood statistics for 2019 derived from Research institute of Sweden (RISE) (Hornborg et al., 2021). Consumption of meat substitutes and plant-based drinks were estimated using house hold statistics from Growth from Knowledge 2021 (GfK, 2023).

Foods excluded from the market basket study were household salt, alcoholic beverages with ≥ 3.5 volume% alcohol, as well as food categories in the SBA´s statistics consumed less than 0.5 kg per person per year (Swedish Board of Agriculture, 2021b). These foodstuffs corresponded to 0.1% (household salt), 8% (alcoholic beverages ≥ 3.5 volume% alcohol), and 0.7% (food categories<0.5 kg/person/year) of the food weight according to the SBA. Hence, the food groups included in the Market Basket 2022 contributed to more than 90% of the food consumption. Tap water was not included in the market basket study (except for the water included in coffee and tea).

7.1.2 Food groups

In the Market Basket 2022, the foods were divided into seventeen major food groups, in which compounds were analysed. In addition, two subgroups were included (pizza/hand pie and processed meat). The foodstuffs in these subgroups were also included in their major food groups pastries and meat, respectively. Table 1 describes the food groups included in the Market Basket 2022 as well as the per capita consumption per food group.

Table 1. Food groups in the Market Basket 2022 and the per capita consumption of these groups.

Food group[1]	Brief description of foods included in the food group	Per capita consumption (g/person/day)
Cereal products[2]	Fluor, grain, breakfast cereals, popcorn, pasta, bread	226
Pastries[2]	Biscuits, buns, cakes, pizza, hand pies	55
Subgroup: pizza, hand pie[2]	Pizza, hand pies	11
Meat[2]	Beef, pork, lamb, poultry, game, processed meats	194
Subgroup: processed meat[2]	Sausage, ham, meatballs, liver paste, bacon, ready-made meat dish	48
Lean fish[3]	Cod, Alaska pollock, canned tuna, shrimps, fish sticks	15
Fatty fish[3]	Salmon, smoked salmon, herring, mackerel, caviar	18
Meat substitutes[4]	Tofu, soy mince, vegetarian sausage/burgers, falafel	3
Lean dairy products[2]	Milk, sour milk, yoghurt	248
Fatty dairy products[2]	Cheese (hard, processed cottage), cream, sour cream	70
Plant-based drinks[4]	Oat, soy and almond drinks, plant-based yoghurt and cream	13
Eggs[2]	Fresh eggs	29
Fats and oils[2]	Butter, margarine, oil, mayonnaise, fatty dressings	55
Vegetables[2]	Fresh, frozen and canned vegetables, ketchup	245
Fruits[2]	Fresh, frozen, canned and dried, nuts, juice, jam	215
Potatoes[2]	Potatoes, French fries, crisps	142
Sugar and sweets[2]	Sugar, chocolate, candy, ice-cream, popsicle	74
Beverages[2]	Soft drinks (with sugar), diet soda, mineral water, beer (≤3.5 vol% alcohol)	262
Coffee and tea[2]	Filter coffee, instant coffee, brewed tea, tea bag	407
Total		2271

[1] Coffee and tea were brewed and analysed as consumed since the powder is not consumed per se. All other products were analysed as purchased, but inedible parts were removed.

[2] Data source: Swedish Board of Agriculture (Swedish Board of Agriculture, 2021b). Preliminary data for year 2020 were used. Therefore, there are some minor changes between data used in Market Basket study 2020 and the final statistics presented by Swedish Board of Agriculture.

[3] Data source: RISE (Hornborg et al., 2021).

[4] Data source: Growth from Knowledge (GfK, 2023). Household statistics from 2021 derived by consumer panels.

A food list was prepared and used as basis when the foods were purchased (see Appendix 1). The distribution of different foods within one food group (e.g. proportions of pasta, bread, rice etc. in the food group cereals) was based on data from the SBA. Food categories in the SBA´s statistics with a consumption of <0.5 kg/person/year were excluded from the food list (Swedish Board of Agriculture, 2021b). Distribution of different foods within each food category (e.g. amount hard bread, soft bread with or without the keyhole symbol) was mainly based on sales statistics from Nielsen IQ 2018 (Nielsen IQ), Growth for Knowledge consumer panel statistics from 2021 (GfK, 2023), and data from the national dietary surveys Riksmaten adults 2010-11 (Amcoff et al., 2012) and Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018a). Which specific brands that were included in the samples were mainly made based on sales statistics from Nielsen IQ 2018 (Nielsen IQ), and ranking of the most popular brands at the grocery stores´ online shops. If a specific brand on the food list could not be found, it was substituted with another brand according to the most popular brand at the grocery store´s online shop, and the food list was revised accordingly.

7.1.3 The per capita concept

In the present report, *per capita consumption* was used when describing average food consumption in the population. Per capita consumption was estimated by dividing the available total volume of a food category (mainly based on the SBA´s statistics) by the number of inhabitants in Sweden (10 353 000 (Swedish Board of Agriculture, 2021a)). The per capita consumption per food group is presented in Table 1.

Per capita intake was used to describe the estimated intake of a compound (both nutrients and potentially harmful substances). Per capita intake was derived by multiplying the per capita consumption for a specific food group with the concentration of the compound found in the food sample. This estimate was given on a per person basis. Figure 1 describes the formulas for calculating the estimated per capita intake of compounds.

Per capita intake from a specific food group:

(concentration of compound in food group) x (per capita consumption [g/person/day])

=

(estimated daily intake of a compound from a specifik food group per person)

Total per capita intake (per person basis):

$\sum(\text{per capita intake per food group})_{\text{all food groups}}$

Total per capita intake (body weight basis):

$\sum(\text{per capita intake per food group})_{\text{all food groups}}$ / 70 kg

Figure 1. Formulas for estimating per capita intake in the Market Basket 2022.

For toxic or potentially harmful contaminants, the intake often needs to be given on body weight basis to be able to compare with health-based reference values. The formula for estimating intake per body weight is given in Figure 1. When converting data to body weight basis, 70 kg was used as a population mean body weight, as recommended by the EFSA (EFSA, 2012b). EFSA´s population mean body weight was considered relevant for the Swedish population because it was in agreement with population mean body weight also when considering population distribution in Sweden (68 kg). In this calculation, weight curves for children (Blomhoff et al., 2023) and weight data from the Public Health Agency of

Sweden´s survey in 2022 (Public Health Agency of Sweden, 2023) for adults were used, see Appendix 2.

The approach for estimating the Swedish average consumer´s intake in the market basket study is an indirect method of monitoring intake, since foods purchased in stores were used as consumption data instead of information from consumers about their actual food consumption. This means that the consumption probably was overestimated as there are no adjustments for e.g. food waste in the retail sector or households (edible parts). Households account for most of the food waste in Sweden (70% of total). Household´s food waste in terms of inedible food parts were adjusted for in the market basket studies, but food waste as edible food parts and liquid food waste were not considered. These were estimated to 15 kg per person and year for edible foods (Hultén et al., 2024) and 18 kg per person and year for liquid foods (Hultén et al., 2024). This corresponded to about 4% of the per capita consumption in the Market Basket 2022. The most frequent foods in household food waste are coffee/tea, followed by dairy products and beverages (juice, soda, alcoholic beverages) (Åkerblom et al., 2021). 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. Results from earlier Swedish market basket studies have shown good agreement with mean exposure estimates from population-based dietary surveys (e.g. dioxins (Darnerud et al., 2006), cadmium (Sand and Becker, 2012)).

7.2 Preparation of the samples

7.2.1 Foods list and collection of food

All foods were purchased in Uppsala, Sweden, between September and November 2022. Since year 2010, the collection of food has been conducted in one city only (Uppsala). In the market basket studies 1999 and 2005, foods were purchased from four cities (Malmö, Gothenburg, Uppsala, and Sundsvall). Because no significant or consistent regional differences were observed in these market basket studies, the regional collection was omitted in the latter three market basket studies. In line with the Market Basket 2015 (Swedish Food Agency, 2017), foods were not purchased over several seasons.

Samples were prepared for nineteen food groups (17 food groups and 2 subgroups), see Table 1. Within each sample, several foods from the food group were homogenised. The proportion of the foods in the sample was based on how much each food was consumed. Three samples were prepared for each food group, consisting of foods that were purchased from Sweden´s three major grocery chains (ICA, Axfood, and Coop). These grocery chains made up to about 90% of the market in year 2022 (ICA [50%], Axfood [21%], Coop [18%]) (DLF and Delfi, 2023). The three samples were made of similar foods but different brands were used. The market basket study is not designed to compare grocery chains, but to obtain a solid food sampling base to be used to estimate national per capita intake. Three different samples were prepared to include food from the major part of the market and to assess variability. In total, 57 samples were prepared (19 per grocery chain) and approximately 260 foodstuffs were purchased for the samples of each grocery chain. If a specific brand constituted more than 15% of a sample (based on the statistics described in section 7.1.2), several batches were included in the sample. Detailed information about number of samples per food group and substance are shown in Appendix 3.

7.2.2 Handling of food and samples

Upon arrival at the Swedish Food Agency, the foods were registered and given an individual record number, allowing the traceability of the foods contained in each sample. The foods were stored at the appropriate temperature (i.e., freezer, refrigerator, room temperature), respectively, until homogenisation and preparation of the samples.

It was important that the prepared samples were homogenous enough to be able to take a small subsample for analyses (sometimes less than 1 g) and that this subsample still was representative of the composition of the entire sample. Another important aspect when preparing the samples was that contamination of the samples must be avoided. However, since a broad spectra of compounds are analysed in the market basket studies, several parallel setups would be needed for all food groups if contamination should be completely avoided (e.g. no stainless steel knives for analyses of nickel or chromium, no plastic for analyses of flame retardants and dioxins). Several parallel sample preparations would however be too costly. Actions to avoid contamination were therefore taken as far as reasonably possible. The approach was generally to prepare the samples with carefully cleaned tools commonly used in a household kitchen. This process is described in more detail below.

The foods were homogenised as purchased, and no cooking was done (with exception of coffee/tea, see below). Only the edible part of the food was included in the samples. Vegetables, fruits and potatoes were peeled when appropriate. Half of the potatoes were peeled and half of the potatoes were homogenised with peel. Fishes were homogenised fileted and without skin, with exception of Baltic herring which was homogenised with skin.

Coffee and tea were brewed before analyses since the powder is not consumed as such. The exception was for the analysis of radionuclides, which was done on a mixture of raw powder of coffee and tea, and not brewed. The results of radionuclides will be presented in a separate report. The dosage and brewing were done according to the product instructions. Pots and other equipment used for brewing were washed with non-perfume detergent and rinsed with acetone. The two most popular brands for coffee filters per grocery chain were used. Tea was brewed using disposable tea bags. It is recommended to use tap water, preferably a pooled sample of several regions, but tap water from e.g. the laboratory is also sufficient (EFSA, 2012b). The laboratory at the Swedish Food Agency is located in a region with higher levels of per- and polyfluoroalkyl substances (PFAS) and fluoride in the drinking water. Also, it was decided that a national collection of tap water was not cost effective since drinking water is not the main aim of the market basket study. Therefore, a water installation with low levels of PFAS (sum of 11 PFAS <5 ng/L) and fluoride (0.1 mg/L) was identified and used for coffee and tea brewing. This water installation (Skråmsta renvatten) was located in the county of Örebro, Sweden. Water was collected in acid-washed plastic cans approved for food.

Equipment used in the homogenisation process was washed with non-perfume detergent and rinsed with acetone. A Retsch GM 300 with a stainless container was used for homogenisation. Some foods were freezed in -70°C before mixing to facilitate the homogenisation process (e.g., some cookies, dried fruits, chocolate, and candy). Depending on type of analyses, the homogenised samples were distributed to plastic containers, acid-washed plastic containers, Falcon tubes, brown glass containers (burned in oven at 300°C over night with tinfoil between container and top). The samples were stored in -70°C (samples for analyses of nutrients) or -20°C (samples for analyses of contaminants or naturally occurring unwanted substances) until analyses.

7.3 Chemical analyses

In general, three samples were analysed per food group and compound. However, all compounds were not analysed in all food groups. Which compounds to be analysed in which food groups were decided based on results from previous market basket studies (i.e. food groups that contained high vs low concentrations of a compound, time trends and margins of exposure estimations to health-based reference values) as well as costs. Appendix 3 shows in which food groups each compound was analysed and the number of samples per food group and compound. The methods for the chemical analyses of all compounds are described in Appendix 4.

7.4 Statistical analyses

Compound concentrations in food groups are described by mean, minimum, median, and maximum values. Because analyses were performed in three samples per food group, the minimum, median, and maximum values each correspond to the concentration of one sample. Because e.g. the maximum concentrations of several compounds could be obtained in different samples, data are presented as minimum, median, and maximum instead of sample 1, sample 2, and sample 3.

Values below quantification limit were for most compounds handled according to a hybrid bound (HB) approach. This means that concentrations below limit of quantification (LOQ) or limit of detection (LOD) was replaced by 0.5*LOQ or 0.5*LOD. However, if all three samples of a food group had concentrations below LOQ/LOD, these concentrations were set to 0. For mycotoxins available machine outputs were used for concentrations below LOQ. In addition, because of the use of toxicity equivalency factors, a medium bound approach was used for PCBs and dioxins (all concentrations <LOQ replaced by LOQ*0.5, see section 8.6.1).

Per capita intake was calculated as described in section 7.1.3. Per capita intake per kg bodyweight was calculated by assuming a population mean body weight of 70 kg (see section 7.1.3). Per capita intakes are described using lower bound (non-detects=0), hybrid or medium bound and upper bound (non-detects=LOQ or LOD) approaches. The hybrid or medium bound approach or machine outputs were used when estimating contribution of different food groups to the per capita intake and when investigating time trends of per capita intake. Compound specific deviations from this approach is described in the section of that specific compound, if any.

Changes over time were examined visually for all compounds analysed in at least one previous market basket study. Time trends of per capita intakes were investigated using linear regression analysis for compounds with a sufficient number of observations, generally with log (ln) transformed concentrations. P-values indicate a change in the per capita intake when we generalise the results to the Swedish population´s consumption of the foods available on the Swedish market. Even though many compounds were analysed in the market basket surveys, no multiple testing adjustments of p-values in time trend analyses were made. This was because the aim of the market basket studies is explorative. Intake from coffee/tea was not included in the time trend analyses. Intake from meat substitutes and plant-based drinks were included in the analyses. For compounds where fish consumption was suspected to drive the total per capita intake, time trend using fish consumption as defined by previous market basket studies was conducted as a sensitivity analysis. This means that the fish consumption was set to 37 g/person/day according to statistics of SBA (Swedish Board of Agriculture, 2021b) instead of 33 g/person/day to see if there were any major changes in the time trend.

8 Results

8.1 Time trends of the per capita consumption

One aim of the market basket studies is to investigate time trends in the estimated exposure of compounds analysed in a recurrent manner. The per capita intake is a function of per capita consumption and compound concentrations in the food groups. Hence, a time trend in per capita intake of a compound could be caused by a change in the consumption, a change in the concentrations or both. Both these aspects must therefore be considered when interpreting time trends in the per capita intake. Time trends in per capita intake of the compounds are presented in the results section for each analysed compound, when applicable. Time trends in per capita consumption of food groups are presented below (Figure 2 and Table 2).

It is important to consider several aspects that contribute to uncertainties when interpreting time trends in the per capita consumption. Firstly, age distribution in the Swedish population has changed over time. Energy requirement and food consumption in the population may change due to this distribution. Secondly, changes in population behaviour regarding food waste could also have an impact on the per capita consumption, even if the actual food consumed is not changed. If a reduction of food waste in households leads to that less foods are bought, this means that the per capita consumption is reduced despite that people are eating the same amount. If, on the other hand, a reduced food waste is concomitant with increased consumption, such increased consumption will not be detected in the per capita consumption. Thirdly, home production of food is not included in the per capita consumption. Therefore, changes in consumption due to home produced food are not captured by market basket studies. Fourthly, the methodology of the market basket studies has been slightly modified over time. For example, changes in aggregation of foods into food groups have differed slightly between the studies, and food purchase has been conducted in different seasons. Also, in the Market Basket 2022, another data source of fish consumption was used and three new food groups were included (meat substitutes, plant-based drinks, and coffee/tea).

Table 3 shows the major changes in the Market Basket 2022 compared with previous market basket studies. The consumption of coffee and tea was not included in the time trends. The reason is that this food group has not been included in previous market basket studies. Therefore, the time trends of per capita consumption, and possibly also intake, would increase if the consumption of coffee and tea was included. Coffee and tea consumption was however included when estimating the exposure assessment in the results, if applicable (i.e., when not investigating time trends).

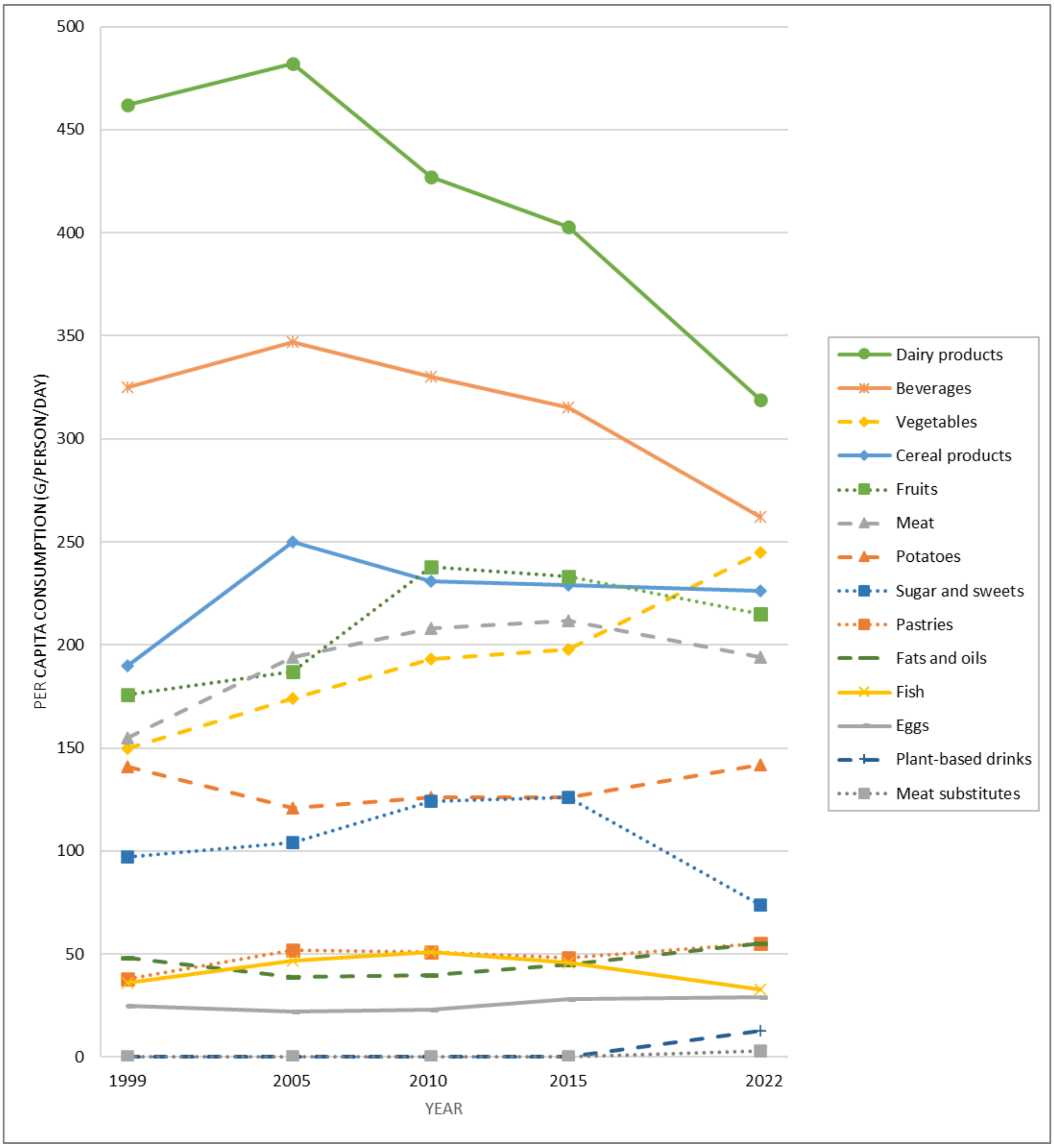

Figure 2. Changes over time of the Swedish per capita consumption (g/person/day) in the five market basket studies conducted between 1999 and 2022.

The food groups meat substitutes and plant-based drinks were not included in the market basket studies before 2022. The consumption of these were therefore set to zero between 1999 and 2015. Coffee/tea are not shown in the figure as this food group was not included in market basket studies before year 2022. Observe that some foodstuffs have been categorized differently in the Market Basket 2022 compared with previous studies (see Table 2 and Table 3).

Table 2. The Swedish per capita consumption (g/person/day) in the market basket studies conducted between 1999 and 2022.

Food group	Per capita consumption (g/person/day)				
	1999	2005	2010	2015	2022
Cereal products	190	250	231	229	226
Pastries	38	52	51	48	55
Meat	155	194	208	212	194
Fish	36	47	51	46	33[1]
Meat substitutes	-	-	-	-	3[2]
Dairy products	462	482	427	403	318[3]
Plant-based drinks	-	-	-	-	13[2]
Eggs	25	22	23	28	29
Fats and oils	48	39	40	45	55[4]
Vegetables	150	174	193	198	245[5]
Fruits	176	187	238	233	215
Potatoes	141	121	126	126	142
Sugar and sweets	97	104	124	126	74[6]
Beverages	325	347	330	315	262
Coffee and tea	-	-	-	-	407[7]
Total	1 844	2 020	2 041	2 008	1864

[1] Sum of lean fish and fatty fish consumption (15 g and 18 g, respectively). Another data source was used in the Market Basket 2022 compared to previous market basket studies. The fish consumption calculated in line with previous studies (based on statistics from the Swedish Board of Agriculture) was 37 g/person/day.

[2] Meat substitutes and plant-based drinks were not included in market basket studies before year 2022.

[3] Sum of lean and fatty dairy products (248 g and 70 g, respectively).

[4] The increase was partly explained by that the consumption of fatty dressings (7 g/person/day) was included in the food group fats/oils in the Market Basket 2022 instead of sugar/sweets as in previous studies.

[5] The increase was partly explained by that the consumption of ketchup (20 g/person/day) was included in the food group vegetables in the Market Basket 2022 instead of sugar/sweets, as in previous studies.

[6] The decrease was partly explained by that the consumptions of fatty dressings (7 g/person/day) and ketchup (20 g/person/day) were included in the food group fats/oils and vegetables, respectively, in the Market Basket 2022.

[7] Coffee/tea were not included in market basket studies before year 2022. This group was not included in the time trends of per capita consumption (and in the total consumption above).

Briefly, per capita consumptions of dairy products, beverages and sugar/sweets decreased in the Market Basket 2022 compared with previous market basket studies, whereas fats/oils and vegetables increased. The decreasing time trend of dairy products was mainly explained by a lower consumption of milk products (milk, sour milk and yoghurt), which was about 80% of the consumed dairy products in the Market Basket 2022. A decreasing time trend of milk products has also been observed among 70-year-old Swedes (Samuelsson et al., 2019). The increases in consumption of fats/oils and vegetables, and the decrease in consumption of sugar/sweets are probably mainly explained by the redistribution of fatty dressings and ketchup from the food group sugar/sweets to fats/oils, and vegetables, respectively. However, increased intake of vegetables has been indicated among 70-year-olds (Samuelsson et al., 2019), whereas another Swedish study observed a rather stable consumption (Törmä et al., 2021). The decrease in the food group sugar/sweets did not seem to be fully explained by the redistribution of fatty dressings and ketchup but also by an actual reduction in consumption of sugar/sweets. A decreased intake of sweets has also been indicated among adults in Northern Sweden (Törmä et al., 2021). The decreasing time trend for beverages was mainly explained by a lower consumption of beer (≤3.5 vol% alcohol). In contrast, intake of soda has rather increased since 2015 (Swedish Board of Agriculture, 2021b, Sveriges bryggerier, 2020). The distribution of sugar-free soda has increased with simultaneous decrease in sugar-sweetened soda (Sveriges bryggerier, 2020). A small decrease in fish consumption was observed in the Market Basket 2022. This could partly, but probably not entirely, be explained by use of another data source. A decrease is also indicated by a stable production of sea food over time with a simultaneous larger population (Hornborg et al., 2021). However, time trends of fish consumption are uncertain and there are also data suggesting a stable trend (Törmä et al., 2021). One must also keep in mind that the pandemic of covid-19 started in year 2020, which could temporarily have influenced the consumption of specific food groups and hence having an impact on the results.

As mentioned above, fish consumption statistic by RISE was used instead of statistic from the SBA. The reason was that the SBA does not produce any data on fresh fish and shellfish after year 2000 due to uncertainty in the data source. Briefly, fish consumption was calculated in a similar way, but the per capita consumption was lower according to RISE (12 kg/person/year (Hornborg et al., 2021)) compared with the SBA (15 kg/person/year). The differences between RISE and the SBA could be due to that different conversation factors from whole fish to editable parts were used, that more whole fish were included in the statistics of the SBA, and/or a negative trend in fish consumption since 1999. Due to the change of fish consumption statistics and inclusion of three new food groups, special consideration for these issues were taken when investigating time trends in the intakes of substances (see section 7.4).

Table 3. Major changes of the food groups and compilation of the food list in the Market Basket 2022 compared with previous market basket studies.

Food group	Change and implication on time trend
Cereals	Corn cereals and popcorn were included in the Market Basket 2022 but not in previous market basket studies. These products were included because of their relatively high consumption. These consumption data were included as other cereals in previous market basket studies, and the change did therefore not affect the time trend of total cereal consumption.
Pastries	The proportion of pizza/hand pie was decreased compared with previous market basket studies as a consequence of updated consumption data (26% and 40% in Market Basket 2022 and Market basket 2015, respectively). This may have affected the time trends of compounds such as sodium, fat, and sugars.
Fish	Updated consumption data from RISE were used instead of older data from Swedish Board of Agriculture, which slightly decrease the estimated consumption (33 g/person/day instead of 37 g/person/day). This may have affected the time trends for compounds with high concentrations in the fish groups. Fish and shellfish were divided into two groups: lean and fatty fish. Previous market basket studies did only have one fish group.
Meat substitutes	New food group not included in previous market basket studies.
Dairy products	Dairy products were divided into two groups: lean and fatty. This categorisation was used for some compounds in the Market basket 2015.
Plant-based drinks	New food group not included in previous market basket studies.
Fats and oils	Fatty dressings (béarnaise sauce) were included in the food group fats/oils in the Market Basket 2022 instead of sugar/sweets, as in previous market basket studies. This affected the time trends of both fats/oils (increased with 7 g/person/day) and sugar/sweets (decreased with 7 g/person/day).
Vegetables	Ketchup was included in the food group vegetables in the Market Basket 2022 instead of sugar/sweets, as in previous market basket studies. This affected the time trends of both vegetables (increased with 20 g/person/day) and sugar/sweets (decreased with 20 g/person/day).
Sugar and sweets	Ketchup and fatty dressings were included in vegetables and fats/oils, respectively in the Market Basket 2022. This decreased the consumption of sugar/sweets with 27 g/person/day.
Coffee and tea	New food group not included in previous market basket studies.
Other	Ready to eat soups and broths were excluded from the food groups meat, fish, and vegetables as the contents of meat, fish and vegetables were very little and hence diluted these food groups. Because of the low consumption of soups and broths (1.6-3.3 g/person/day per food group), the impact on the time trends were considered limited.
Number of samples	Samples from three different grocery chains were included in the Market Basket 2022 compared with five in previous studies. Instead, number of food groups were increased in the Market Basket 2022.

8.2 Macronutrients

Macronutrients are energy-giving nutrients required in larger quantities. They provide us with energy needed by all cells in the body. The main contributors to energy in foods are carbohydrates (17 kJ/g [4 kcal/g]), proteins (17 kJ/g [4 kcal/g]), fats (37 kJ/g [9 kcal/g]), and dietary fibres (8 kJ/g [2 kcal/g]). Alcohol also provides energy (29 kJ/g [7 kcal/g]), but is not included in the recommended intake of energy in the Nordic Nutrition Recommendations (NNR) (Blomhoff et al., 2023). Protein, fat, carbohydrate and dietary fibre were assessed in the Market Basket 2022. Also, individual fatty acids and different kinds of carbohydrates (starch and sugars) were measured.

Total fat, mono- and disaccharides, water, ash and protein (as nitrogen) were analysed by Eurofins Food & Feed Testing Sweden in Linköping. Starch was analysed by Eurofins Food & Feed Testing Norway. Resistant starch was not included in the starch analysis, but free glucose was included in the analysis for the food groups meat, processed meat, lean and fatty fish, lean and fatty dairy products, egg, and fats/oils. High molecular weight dietary fibres (HMWDF) (including resistant starch) and low molecular weight dietary fibres (LMWDF) were analysed by Eurofins Food & Feed Testing Netherlands. Fatty acids were analysed using gas chromatography by the Swedish Food Agency. All laboratories were accredited. Methods, measurement uncertainties, and LOQs are shown in Table 4. The chemical analyses are described in more detail in Appendix 4 (section A 4.1).

Protein was calculated using the standard nitrogen conversion factor of 6.25 (Regulation (EU) No 1169/2011). Using specific nitrogen conversion factors for individual food groups did only have minor impact on the per capita intake of protein (less than 2 g/day in difference). For simplicity, the factor of 6.25 was therefore used in this report. Total carbohydrate was calculated by difference, i.e. 1000 g - water (g/kg) - ash (g/kg) - fat (g/kg) - protein (g/kg) - total fibre (g/kg). Alcohol was not analysed in the Market Basket 2022 and not included in the calculation. Total fibre content was calculated as the sum of HMWDF (including resistant starch) and LMWDF. Energy content was calculated by the formulas (17*protein (g/kg) + 37*fat (g/kg) + 17*carbohydrates (g/kg) + 8*fibres (g/kg)), and (4*protein (g/kg) + 9*fat (g/kg) + 4*carbohydrates (g/kg) + 2*total fibres (g/kg)) for kJ and kcal, respectively (Regulation (EU) No 1169/2011). Total fibre content was assumed to be zero for the food groups lean and fatty dairy products, fats/oils, eggs, and beverages in the calculations of total carbohydrates and energy contents. Fat and protein contents in the food group beverages were also assumed to be zero in the calculation of energy content. The formulas for calculating the groups of fatty acids are shown in Appendix 4 (section A 4.1).

Table 4. Limit of quantification (LOQ) and measurement uncertainty for analyses of macronutrients in the Market Basket 2022.

Substance	LOQ	Measurement uncertainty
Fat, total[1]	1 g/kg	±10%
Fatty acids (FA)	0.1%	±34% if FA ≤0.5% ±7% if FA >0.5-6% ±5% if FA >6% ±10% total trans FAs
Nitrogen (Kjeldahl)[2]	0.5 g/kg	±10%
Fibre, total		
High molecular weight fibres + resistant starch	4 g/kg	±18.5%
Low molecular weight fibres	2 g/kg	±15.4-22.0%
Starch	10 g/kg	15%
Glucose	0.4 g/kg	±15-25%
Fructose	0.4 g/kg	±15-25%
Sucrose	0.4 g/kg	±15-30%
Lactose	0.4 g/kg	±15-25%
Maltose	0.4 g/kg	±15-25%
Galactose	0.4 g/kg	±25%
Ash	1 g/kg	±10%
Water[3]	1 g/kg	±10%

1 g/kg = 0.1 g/100 g.

[1] Lean dairy products: LOQ = 0.02 g/kg, measurement uncertainty = ±8%.

[2] Fats and oils: LOQ = 0.5 g/kg, measurement uncertainty = ±20%.

[3] Fats and oils: LOQ = 1 g/kg, measurement uncertainty = ±25%. Lean and fatty dairy products: LOQ = 1 g/kg, measurement uncertainty = ±10%.

8.2.1 Concentrations in food groups

Concentrations of macronutrients, nitrogen, water, and ash in the different food groups in the Market Basket 2022 are presented in Table 5 together with energy content estimations. The concentrations of fatty acids and different carbohydrates are shown in Table 6 and Table 7,, respectively. Nutrient claims are regulated according to the EU regulation for nutrient claims (Regulation (EC) No 1924/2006). The purpose of the regulation is to harmonise the provisions for nutrition and health claims for commercial communication of individual products. An evaluation of the nutrient content of the food groups in the Market Basket 2022 was done using the EU regulation 1924/2006 (Regulation (EC) No 1924/2006). It should however only be considered as an indication, and individual food items can still fulfil the requirements for a nutrient claim although the food group has a content below the requirement.

Energy

The highest energy content was obtained in fats/oils followed by sugar/sweets and pastries (Table 5). Vegetables was the only food group with enough energy content to fulfil the criterion for the claim low in energy (i.e. 170 kJ/100 g for solids and 80 kJ/100 mL for liquids (Regulation (EC) No 1924/2006)).

Protein

Fatty dairy products, meat, and fatty fish had the highest protein concentrations if not considering energy content (Table 5). A claim that a food is high in protein may be made where at least 20% of the energy value of the food is provided by protein (Regulation (EC) No 1924/2006). This criterion was fulfilled for lean fish (73% of energy from protein), meat (40%), eggs (36%), meat substitutes (34%), fatty fish (33%), lean dairy products (27%), fatty dairy products (23%), and processed meat (21%). Vegetables (16% of energy from protein) and cereal products (14%) fulfilled the criterion for a food to be claimed as a source of protein, i.e. at least 12% of the energy from protein (Regulation (EC) No 1924/2006).

Fat and fatty acids

The highest total fat concentration was measured in fats/oils, followed by fatty dairy products and processed meat (Table 5). Lean fish, vegetables, fruits and potatoes had a fat content of no more than 3 g per 100 g, which is the criterion to claim that a food is low in fat (Regulation (EC) No 1924/2006). Because of the high total fat content in fats/oils, this food group contained the highest concentrations of all determined subgroups of fat except for trans fatty acids (TFA), (i.e. saturated fatty acids [SFA], monounsaturated fatty acids [MUFA], polyunsaturated fatty acids [PUFA], n-3 PUFA and n-6 PUFA), see Table 6. The highest concentrations of MUFA found in fats/oils were followed by processed meat, pastries, fatty fish and fatty dairy products. The highest concentrations of PUFA in fats/oils were followed by fatty fish for total PUFA and n-3 PUFA, and by meat substitutes and pastries for n-6 PUFA. The second highest concentrations of SFA (in addition to fats/oils) and the highest concentrations of TFA were detected in fatty dairy products. The food groups cereals, fruits and potatoes had a content of no more than 1.5 g per 100 g and less than 10% of energy from the sum of SFA and TFA, which is the criterion to claim that a food is low in saturated fat (Regulation (EC) No 1924/2006). Individual fatty acids were not analysed in the food groups vegetables, beverages and coffee/tea due to their low fat content. Proportion of individual fatty acids of total fatty acids are presented in Appendix 5 (section A 5.1).

Carbohydrates and dietary fibres

Sugar/sweets, cereal products and pastries had the highest contents of total carbohydrates (Table 5). Starch (excluding resistant starch) was most prevalent in cereal products and pastries, whereas the highest concentrations of dietary fibres (including resistant starch) were detected in potatoes, cereal products and meat substitutes (Table 7). High concentrations of both HMWDF (including resistant starch) and LMWDF were seen in cereal products, but the highest concentration of HMWDF were detected in potatoes (Table 7). Cereal products, potatoes and vegetables fulfilled the criterion to claim that a food is high in fibre (i.e. at least 6 g per 100 g or 3 g per 100 kcal (Regulation (EC) No 1924/2006)). Fibre contents in pastries, meat substitutes, and fruits were in accordance with the criterion for foods to be claimed as a source of fibre (i.e. at least 3 g per 100 g or 1.5 g per 100 kcal (Regulation (EC) No 1924/2006)).

Whole grain is defined as the whole kernel of the cereal (the bran, the germ, and the endosperm). There are no chemical analyses to detect the whole grain content of a food item. The content of whole grains was therefore estimated based on product information. The calculations were conducted for the food groups cereal products and pastries. The food group cereal products were estimated to contain approximately 17 g whole grains per 100 g. The food group pastries were estimated to contain approximately 2.7 g whole grains per 100 g.

The highest sugar concentration was found in sugar/sweets, followed by pastries and fruits (Table 7). A food can be claimed to be low in sugars if it contains no more than 5 g per 100 g for solids or 2.5 g per 100 mL for liquids (Regulation (EC) No 1924/2006)). This criterion was obtained for the food groups meat, processed meat, fatty and lean fish, meat substitutes, fatty dairy products, eggs, fats/oils, and potatoes. The content of individual mono- and disaccharides are shown in Table 7. Added sugars are refined sugars used as such or added during food preparation and manufacturing. Free sugars include added sugars but also sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates. Since there is a recommendation on the intake of added and free sugars (Blomhoff et al., 2023), it was deemed relevant to also estimate the content of free sugars in the Market Basket 2022. The definition of free sugars, and not added sugars, was used when estimating the content in the Market Basket 2022 because free sugars are more inclusive (Sonestedt and Overby, 2023). The estimations were conducted according to the procedure used in the Swedish Food Composition Database (Wanselius et al., 2019, Swedish Food Agency, 2023), and were based on chemically analysed concentration data, product information and data from the Swedish Food Composition Database. The highest estimated contents of free sugars were obtained in sugar/sweets (52 g/100 g) and pastries (18 g/100 g), followed by the food groups beverages, fatty fish, fruits (approximately 4 g/100 g each), cereal products (3 g/100 g), and vegetables (2 g/100 g). The other food groups had less than 2% estimated free sugar content. The sources of free sugar in fatty fish were mainly pickled herring, but also mackerel in tomato sauce and caviar to some extent.

Table 5. Concentrations of macronutrients, nitrogen, ash and water per kg in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	*Pizza, hand pie*	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
Energy[1] (MJ/kg)	Mean	13	16	NA	7.6	10	3.8	9.2	7.9	2.2	13	2.4	5.9	25	1.5	4.0	3.6	17	0.85	NA
	Min	13	16		7.3	10	3.8	8.7	7.4	2.1	13	2.3	5.9	25	1.5	3.9	3.5	16	0.77	
	Median	13	16		7.6	10	3.8	9.0	7.9	2.2	13	2.5	5.9	25	1.5	4.0	3.6	17	0.82	
	Max	14	17		7.7	11	4.0	9.8	8.4	2.2	13	2.6	6.0	26	1.6	4.2	3.8	17	0.97	
Energy[1] (kcal/kg)	Mean	3146	3868	NA	1813	2491	912	2197	1894	519	3183	583	1426	6197	363	963	873	3955	200	NA
	Min	3100	3803		1763	2412	891	2078	1780	507	3138	541	1416	6117	352	932	837	3891	180	
	Median	3129	3807		1818	2528	904	2154	1887	523	3161	587	1427	6185	361	956	864	3954	192	
	Max	3210	3993		1857	2535	940	2358	2014	528	3249	619	1433	6289	377	1001	920	4021	228	
Fat (g/kg)	Mean	36	158	NA	117	197	23	143	104	19	252	25	99	673	3.9	27	19	104	0*	NA
	Min	31	147		115	192	20	132	90	18	246	17	99	662	3.6	25	17	98		
	Median	37	160		117	200	22	133	107	19	249	27	99	669	3.8	26	20	104		
	Max	40	167		118	200	26	164	116	20	261	32	99	687	4.2	30	20	110		
Nitrogen (g/kg)	Mean	17	11	NA	28	20	26	28	25	5.5	29	2.4	20	0.80	2.3	2.8	3.3	6.2	0*	NA
	Min	17	11		26	20	26	26	25	5.4	28	2.0	20	0.80	2.2	2.3	3.0	5.7		
	Median	17	12		29	20	26	29	25	5.5	28	2.3	20	0.80	2.4	2.4	3.3	6.3		
	Max	18	12		30	21	27	30	25	5.7	29	2.8	20	0.80	2.4	3.6	3.7	6.7		
Protein[2] (g/kg)	Mean	108	72	NA	176	125	165	176	156	35	179	15	125	5.0	15	17	21	39	0*	NA
	Min	105	71		161	122	163	163	155	34	176	13	124	5.0	14	14	19	36		
	Median	107	72		181	124	164	182	156	34	177	14	124	5.0	15	15	21	39		
	Max	113	72		187	129	168	184	157	36	183	18	127	5.0	15	23	23	42		
Carbohydrates[3] (g/kg)	Mean	566	523	NA	12	54	11	46	56	52	50	71	8.6	31	55	150	105	707	50	NA
	Min	546	503		0	47	3.5	36	47	51	47	67	7.8	22	53	147	99	694	45	
	Median	560	531		18	54	4.0	49	60	52	49	68	7.8	35	55	149	102	707	48	
	Max	590	536		18	60	24	52	61	53	54	77	10	36	58	153	114	720	57	
Fibres[4] (g/kg)	Mean	64	33	NA	4.3	0	3.0	10	53	0*	0*	6.7	0*	0*	24	26	100	18	0*	NA
	Min	62	30		<6	<6	<6	7	52			5			22	25	88	17		
	Median	62	33		2	<6	<6	11	54			7			25	26	105	18		
	Max	68	36		5	<6	5	11	54			8			26	27	106	18		

		Cereal products	Pastries	*Pizza, hand pie*	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
Ash (g/kg)	Mean	13	14	NA	17	28	15	21	22	7.3	26	6.9	8.7	12	7.5	5.2	10	9.0	0	1.5
	Min	13	13		16	26	13	20	22	7.1	24	5.3	8.6	11	7.1	5.2	8.9	8.2	<1	1.3
	Median	13	14		17	28	15	22	22	7.4	27	7.5	8.7	11	7.4	5.2	11	8.2	<1	1.4
	Max	14	14		18	31	16	22	22	7.4	28	7.9	8.9	12	7.9	5.3	12	11	<1	1.7
Water (g/kg)	Mean	213	200	480	678	595	784	603	608	887	493	876	759	280	894	775	745	123	950	990
	Min	191	182	480	665	590	773	588	593	886	487	874	757	274	891	769	731	115	943	989
	Median	220	200	480	682	590	789	600	613	886	489	875	758	279	894	776	741	115	952	990
	Max	228	219	481	686	606	791	621	619	889	503	878	761	287	898	779	763	140	955	990

1 g/kg = 0.1 g/100 g.

NA, not analysed; 0*, content was assumed to be logical zero and no analyses were performed.

< indicates a value below limit of quantification (LOQ). When calculating means as well as energy, carbohydrate and total fibre contents, hybrid bound approach was used. This means that medium bound concentration (0.5*LOQ) was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

[1] Calculated by the formulas (17*protein (g/kg) + 37*fat (g/kg) + 17*carbohydrates (g/kg) + 8*fibres (g/kg)), and (4*protein (g/kg) + 9*fat (g/kg) + 4*carbohydrates (g/kg) + 2*total fibres (g/kg)) for kJ and kcal, respectively (Regulation (EU) No 1169/2011).

[2] Protein content was calculated using the standard nitrogen conversion factor of 6.25 (Regulation (EU) No 1169/2011).

[3] Carbohydrates were calculated by difference, i.e. 1000 g - water (g/kg) - ash (g/kg) - fat (g/kg) - protein (g/kg) - total fibre (g/kg). Negative contents were replaced by zero (i.e. concentrations of one meat sample and upper bound concentration of one fish sample).

[4] Total fibre content was calculated as the sum of resistant starch, high molecular weight dietary fibres (HMWDF) and low molecular weight dietary fibres (LMWDF). < are the sum of both LOQ (HMWDF: <4 g/kg, LMWDF: <2 g/kg). If one fibre type had concentration <LOQ, the quantified concentration of the other type was shown.

Table 6. Concentrations of fatty acids per kg in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets
FA factor[1]		0.73	0.96	0.95	0.95	0.70	0.90	0.80	0.94	0.94	0.94	0.83	0.96	NA	0.93	0.96	0.96
Fat, total	Mean	36	158	117	197	23	143	104	19	252	25	99	673	3.9	27	19	104
(g/kg)	Min	31	147	115	192	20	132	90	18	246	17	99	662	3.6	25	17	98
	Median	37	160	117	200	22	133	107	19	249	27	99	669	3.8	26	20	104
	Max	40	167	118	200	26	164	116	20	261	32	99	687	4.2	30	20	110
SFA	Mean	3.4	59	47	75	2.0	22	21	13	166	2.4	25	193	NA	3.6	3.4	53
(g/kg)	Min	3.1	54	46	74	1.9	20	14	12	160	1.6	25	188		2.9	1.5	50
	Median	3.3	60	47	75	2.0	20	23	13	164	2.8	25	190		3.8	2.1	52
	Max	3.9	62	47	76	2.2	25	27	13	173	2.9	26	200		4.2	6.5	56
MUFA	Mean	12	69	53	93	8.4	67	37	4.5	62	13	40	316	NA	16	10	39
(g/kg)	Min	10	66	53	90	7.6	59	29	4.2	61	8.6	38	314		14	8.1	36
	Median	12	67	54	93	8.0	64	40	4.4	62	14	41	316		15	11	39
	Max	15	75	54	94	9.5	79	42	4.8	63	17	41	319		18	12	42
PUFA	Mean	10	24	9.9	19	5.4	40	25	0.58	7.7	7.8	17	133	NA	5.6	4.3	7.8
(g/kg)	Min	9.0	21	9.2	17	4.7	36	22	0.53	7.3	5.3	16	128		5.5	2.5	6.9
	Median	11	24	10	19	5.4	39	24	0.60	7.7	8.5	17	131		5.7	4.4	8.0
	Max	11	25	11	20	6.2	44	30	0.61	7.9	9.5	18	139		5.7	6.1	8.5
n-3 PUFA	Mean	1.4	4.3	0.87	1.4	2.9	23	4.5	0.10	1.0	1.6	2.0	36	NA	0.58	0.21	0.29
(g/kg)	Min	1.1	3.7	0.77	1.2	2.6	20	2.8	0.09	0.98	1.1	1.8	34		0.55	0.19	0.25
	Median	1.5	4.4	0.91	1.4	3.1	22	5.2	0.11	1.0	1.7	1.9	35		0.59	0.19	0.28
	Max	1.7	4.8	0.93	1.6	3.1	26	5.5	0.11	1.1	2.0	2.1	39		0.61	0.27	0.33
18:3 n-3	Mean	1.4	4.3	0.87	1.2	0.85	5.7	4.5	0.10	1.0	1.6	0.92	36	NA	0.58	0.21	0.29
(g/kg)	Min	1.1	3.7	0.77	1.1	0.68	5.4	2.8	0.09	0.98	1.1	0.85	34		0.55	0.19	0.25
	Median	1.5	4.4	0.91	1.2	0.78	5.4	5.2	0.11	1.0	1.7	0.92	35		0.59	0.19	0.28
	Max	1.7	4.8	0.93	1.4	1.1	6.5	5.5	0.11	1.1	2.0	1.0	39		0.61	0.27	0.33
n-6 PUFA	Mean	9.0	18	8.2	16	2.4	16	21	0.28	4.2	6.2	15	88	NA	5.0	4.1	6.7

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets
(g/kg)	Min	8.0	17	7.5	15	2.1	14	17	0.25	4.1	4.2	14	85		4.9	2.2	6.0
	Median	9.2	19	8.2	17	2.3	16	18	0.28	4.2	6.8	15	87		5.1	4.2	6.7
	Max	9.8	19	8.8	17	3.0	17	27	0.29	4.3	7.4	16	91		5.1	5.9	7.3
TFA	Mean	0.00	0.48	1.6	0.79	0.05	0.88	0.27	0.73	10	0.00	0.11	6.7	NA	0.00	0.03	0.51
(g/kg)	Min	0.00	0.40	1.5	0.71	0.04	0.75	0.25	0.68	10	0.00	0.10	5.8		0.00	0.01	0.45
	Median	0.00	0.46	1.5	0.77	0.05	0.85	0.26	0.72	10	0.00	0.11	6.5		0.00	0.04	0.50
	Max	0.00	0.57	1.7	0.91	0.06	1.0	0.30	0.78	10	0.00	0.12	7.7		0.00	0.05	0.57

1 g/kg = 0.1 g/100 g. Hybrid bound approach are used for values below limit of quantification. Concentrations estimated by lower bound and upper bound approaches as well as percentage proportion of individual fatty acids are presented in Appendix 5 (section A 5.1).

NA, not analysed; FA factor, fatty acid factor; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, trans fatty acids. Concentrations were estimated using the hybrid bound approach. This means that medium bound concentration (0.5*limit of quantification [LOQ]) was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects.

[1] FA was not analysed in vegetables due to low total fat content (<0.5% fat). Fat content in beverages and coffee/tea were assumed to be logical zero and no analyses were performed. FAs were not analysed in subgroups pizza/hand pies.

[2] Total fat content was converted into gram fatty acids by a FA factor according to (Greenfield and Southgate, 2003), with the following exceptions: For cereal products and fruits, mean FA factors were calculated based on total fat and fatty acid contents of the individual food items in the food group, respectively. Fat content data from Swedish Food Agency´s food composition database was used. For pastries, potatoes and sugar/sweets, FA factor for fats and oils (0.96) were used because most fat were from fats and oils. For meat and processed meat, FA factor for bovine and poultry (0.95) was used because it was closest to estimated mean FA factor (0.94). For meat substitutes, FA factor for vegetables were used. For plant-based drinks, FA factor for oat was used because most of the sample was oat milk (64%).

Table 7. Concentrations of carbohydrates per kg in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
Starch[1,2] (g/kg)	Mean	507	324	7.7	34	20	0	38	0	0	10	0	0	0	8.0	141	107	0
	Min	496	309	<10	24	15	<10	33	<10	<10	<10	<10	<10	<10	<10	128	89	<10
	Median	512	318	<10	31	19	<10	36	<10	<10	12	<10	<10	<10	<10	145	107	<10
	Max	512	345	13	48	25	<10	45	<10	<10	14	<10	<10	<10	14	149	125	<10
Fibres, total (g/kg)[3]	Mean	64	33	4.3	0	3.0	10	53	NA	NA	6.7	NA	NA	24	26	100	18	NA
Fibres, total (g/MJ)[3]	Mean	4.8	2.0	0.58	0	0.78	1.1	6.8	NA	NA	2.8	NA	NA	16	6.4	27	1.1	NA
HMWDF + resistant starch (g/kg)	Mean	51	26	3.0	0	3.0	4.3	44	NA	NA	4.0	NA	NA	21	24	96	14	NA
	Min	49	24	<4	<4	<4	<4	43			3			19	24	84	13	
	Median	49	26	<4	<4	<4	4	44			4			21	24	102	14	
	Max	56	29	5	<4	5	7	45			5			22	25	102	14	
LMWDF (g/kg)	Mean	13	6.7	1.3	0	0	6.0	9.3	NA	NA	2.7	NA	NA	3.7	1.7	3.7	4.0	NA
	Min	12	6	<2	<2	<2	4	9			2			3	1	3	4	
	Median	13	7	<2	<2	<2	7	9			3			4	2	4	4	
	Max	13	7	2	<2	<2	7	10			3			4	2	4	4	
Sugars, total (g/kg)[4]	Mean	50	191	8.5	13	2.3	46	15	49	9.4	33	3.1	11	58	162	9.3	560	47
Fructose (g/kg)	Mean	13	21	0.67	0	0	1.3	1.9	0.33	0	0.63	0	0.90	29	88	3.1	31	13
	Min	12	17	0.5	<0.4	<0.4	0.8	1.1	<0.4	<0.4	<0.4	<0.4	0.7	20	85	2.2	28	7.8
	Median	12	21	0.7	<0.4	<0.4	1.2	2.1	0.4	<0.4	0.8	<0.4	0.9	30	86	3.5	31	14
	Max	14	25	0.8	<0.4	<0.4	2.0	2.6	0.4	<0.4	0.9	<0.4	1.1	36	92	3.7	33	16
Glucose (g/kg)	Mean	11	21	4.9	7.4	0.70	2.5	1.1	1.4	0.30	1.5	3.1	1.1	29	74	3.0	60	12
	Min	10	18	3.7	4.6	0.6	2.2	<0.4	1.3	<0.4	0.8	3.0	0.9	27	73	1.9	55	7.5
	Median	10	21	4.9	5.7	0.6	2.4	1.4	1.4	<0.4	1.4	3.1	1.1	28	74	3.4	59	13
	Max	12	25	6.1	12	0.9	2.8	1.7	1.4	0.5	2.4	3.2	1.2	33	76	3.8	66	15
Galactose (g/kg)	Mean	0	0	0	0	0	0	0	2.2	0	0	0	0	0	0	0	0	0
	Min	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	2.2	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
	Median	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	2.2	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Max	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	2.2	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sucrose (g/kg)	Mean	3.2	134	1.1	3.7	0	42	2.4	5.8	0	8.2	0	6.4	0	0	0.90	413	23
	Min	3.0	119	0.7	2.3	<0.4	35	<0.4	5.7	<0.4	7.7	<0.4	5.4	<0.4	<0.4	<0.4	391	13
	Median	3.1	134	0.9	2.7	<0.4	40	3.2	5.7	<0.4	7.8	<0.4	6.7	<0.4	<0.4	<0.4	402	26
	Max	3.4	148	1.7	6.2	<0.4	52	3.9	5.9	<0.4	9.2	<0.4	7.1	<0.4	<0.4	2.3	445	29
Maltose (g/kg)	Mean	24	9.4	1.1	0.97	1.6	0	9.2	0	0	22	0	0	0.53	0.37	2.2	17	0
	Min	21	8.4	0.9	0.7	<0.4	<0.4	5.5	<0.4	<0.4	20	<0.4	<0.4	0.5	<0.4	0.8	11	<0.4
	Median	22	9.6	1.0	0.8	1.0	<0.4	8.6	<0.4	<0.4	23	<0.4	<0.4	0.5	<0.4	1.7	18	<0.4
	Max	29	10	1.3	1.4	3.7	<0.4	14	<0.4	<0.4	23	<0.4	<0.4	0.6	0.7	4.2	23	<0.4
Lactose (g/kg)	Mean	0	6.0	0.77	0.57	0	0	0	39	9.1	0	0	2.3	0	0	0	39	0
	Min	<0.4	5.3	0.6	<0.4	<0.4	<0.4	<0.4	39	8.5	<0.4	<0.4	2.2	<0.4	<0.4	<0.4	31	<0.4
	Median	<0.4	6.0	0.7	<0.4	<0.4	<0.4	<0.4	40	8.9	<0.4	<0.4	2.2	<0.4	<0.4	<0.4	32	<0.4
	Max	<0.4	6.8	1.0	1.3	<0.4	<0.4	<0.4	40	10	<0.4	<0.4	2.5	<0.4	<0.4	<0.4	55	<0.4

1 g/kg = 0.1 g/100 g. No analyses were performed in the food groups pizza/hand pies, and coffee/tea.

NA, not analysed; HMWDF, high molecular weight dietary fibre; LMWDF, low molecular weight dietary fibre. < indicates a value below limit of quantification (LOQ). When calculating mean hybrid bound approach was used. This means that medium bound concentration (0.5*LOQ) was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

[1] Resistant starch was not included in the analysis.

[2] Free glucose was included in the starch analysis for the food groups meat, processed meat, lean and fatty fish, lean and fatty dairy products, egg, fats and oils.

[3] Total fibres were calculated as the sum of HMWDF and LMWDF.

[4] Total sugars were calculated as the sum of fructose, glucose, galactose, sucrose, maltose and lactose.

8.2.2 Exposure estimations and time trends

Estimated mean intake of macronutrients, fatty acids, and different carbohydrates in the Swedish population are presented in Table 8, Table 9, and Table 10. The proportional contribution of each food group to the per capita intakes of energy and proteins are presented in Figure 3. The contribution of food groups to intakes of fatty acids and different carbohydrates are illustrated in Figure 4, Figure 5, and Figure 6. Time trends of per capita intakes in comparison with previous market basket studies are shown in Figure 7.

Energy

The estimated per capita intake in the Market Basket 2022 was 12 MJ/day (Table 8). This was higher than reported in Riksmaten adults 2010-11 (8.3 MJ/day (Amcoff et al., 2012)) and Riksmaten adolescents 2016-17 (8.9 MJ/day (Warensjö Lemming et al., 2018a)). This is not surprising because the market basket studies do not consider food waste and therefore tend to overestimate the consumption. In contrast, food consumption is often underreported in dietary surveys and energy intake is often difficult to assess accurately (Poslusna et al., 2009). Estimated total energy intake in the Market Basket 2022 was slightly lower than estimated in the Market Basket 2015 (Figure 7). This is explained by a lower total amount of per capita consumption in the present study (1.9 kg vs 2.0 kg per person per day if coffee and tea was excluded). Similar MJ per kg food was seen in both studies (6.4 MJ/kg in Market Basket 2022 and 6.2 MJ/kg in Market Basket 2015). One contributing factor to the lower amount of consumed food in the Market Basket 2022 compared with previous could be reduced amount of food waste in Sweden (Hultén et al., 2024). Cereal products (25%), meat (12%), and fats/oils (12%) contributed the most to the per capita intake of energy (Figure 3). The distribution of energy intake between macronutrients were in accordance with results from Riksmaten adults 2010-11 (Amcoff et al., 2012) and Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018a) (Table 8).

Protein

The estimated per capita intake of protein was 107 g/day, corresponding to 15 E% (Table 8). This was similar as in Market Basket 2015 (Figure 7), but higher than reported in the Riksmaten surveys (81 g/day (Amcoff et al., 2012) and 88 g/day (Warensjö Lemming et al., 2018a), respectively). However, when adjusting for energy intake, comparable energy percentage intakes of protein were observed (17 E% (Amcoff et al., 2012, Warensjö Lemming et al., 2018a)). Meat (32%), cereal products (23%), and fatty dairy products (12%) contributed to two-thirds of the protein intake (Figure 3).

Fat and fatty acids

Estimated mean total fat intake in the Swedish population was 122 g/day (Table 9), corresponding to 38 E% (Table 8). This was higher than the intakes in the Riksmaten surveys (85 g/d [35 E%] (Amcoff et al., 2012), and 77 g/day [34 E%] (Warensjö Lemming et al., 2018a). Almost two-thirds of the total fat intake were from the food groups fats/oils (30%), meat (18%), and fatty dairy products (14%) (Figure 4). The majority of the fatty acid intake was SFA and MUFA (39% and 44% of total fatty acids, respectively), see Table 9. The estimated per capita intake of SFA was 45 g per day corresponding to 39 E%. The per capita intakes of MUFA and PUFA were 50 g per day (16 E%) and 17 g per day (5 E%), respectively. Of the PUFA, about 80% were n-6 PUFA (13 g/d, 4 E%) and 20% were n-3 PUFA (4 g/day, 3 E%). The absolute intakes were higher than observed in the Riksmaten surveys, whereas the intakes in terms of E% were similar (Table 9) (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). Estimated intake of TFA was 1.7 g per day, corresponding to 0.5 E%. The intake of TFA is not determined in the Riksmaten surveys, why no comparisons could be made.

Contributions of each food group to estimated intake of different fatty acids are illustrated in Figure 4. Fatty dairy products, fats/oils and meat were the major contributors to the per capita intakes of SFA, MUFA and TFA. Almost half of the TFA intake was from fatty dairy products. Most of the per capita intake of PUFA (total, n-3 and n-6) were attributed to fats/oils (37-56%). The second largest contributor was cereals for total PUFA and for n-6 PUFA (approximately 15%), whereas it was fatty fish for n-3 PUFA (12%).

There were no major time trends for the fatty acid intakes (Figure 7). Even though there was a small decrease in total fat intake compared to the Market Basket 2015, the decrease was general across most food groups and the energy percentage was similar between the studies (38 E%). Both the fat content and the per capita intake of fat from sugar/sweets were decreased compared to the Market Basket 2015, but this was attributed to that fatty dressings were included in sugar/sweets in the Market Basket 2015 and fats/oils in the Market Basket 2022 (see Table 3).

Estimated per capita intake of TFA was slightly higher in the present market basket study compared with the Market Basket 2015 (1.7 g/day and 0.5 E% vs 1.0 g/day and 0.3 E%) (Swedish Food Agency, 2017). There was however no time trend in per capita intakes across all market basket studies and the current TFA intake was in line with data from 2010 (Figure 7). The slightly higher estimated intake seems to be attributed to higher concentrations of TFA in meat, fatty dairy products and fats/oils. It may be explained by higher proportion of bovine meat in the meat group and a reduced proportion of oils in fats/oils.

Carbohydrates and dietary fibres

Total carbohydrates

The per capita intake of total carbohydrates was about 306 g/day (Table 10), corresponding to 44 E% (Table 8). Total intake was higher than reported in the Riksmaten surveys (212 g/day (Amcoff et al., 2012) and 242 g/day (Warensjö Lemming et al., 2018a)), but when adjusting for energy intake, similar energy percentages were seen (44 E% (Amcoff et al., 2012) and 46 E%

(Warensjö Lemming et al., 2018a)). Cereal products contributed the most to the per capita intake of total carbohydrates (42%), followed by sugar/sweets (17%) and fruits (11%) (Figure 5).

Sugar and starch

Estimated per capita intake of starch and sugars were 164 g/day and 143 g/day. The most abundant sugar was sucrose (34%), followed by glucose and fructose (25% each). An overall decrease in glycaemic carbohydrates were indicated since 2005, but no change was seen since the latest market basket study in 2015 (Figure 7). Sugar/sweets and fruits seemed to account for most of the reduced estimated sugar intake compared with Market Basket 2015 (Swedish Food Agency, 2017). The reduction of fruits may be attributed to a reduced sugar content in jams and fruit/berry drinks. Interpretation of the reduction of sugar/sweets is limited by that ketchup was included in vegetables instead of sugar/sweets in the present market basket study compared with previous. Thereby, the sugar/sweet´s sugar concentration was increased whereas its per capita intake was decreased. Contributions of each food group to estimated intake of carbohydrate constituents are illustrated in Figure 5 and Figure 6. Cereal products contributed to 70% of the starch intake, followed by potatoes (12%) and pastries (11%). For total sugars, the major sources for per capita intake were sugar/sweets (29%), fruits (24%), and vegetables (10%).

Per capita intake of free sugars was estimated according to the procedure used in the Swedish Food Composition Database (Wanselius et al., 2019, Swedish Food Agency, 2023), see section 8.2.1. Per capita intake of free sugars in Market Basket 2022 was estimated to 89 g/day, corresponding to 12 E%. This was in accordance with energy-adjusted intake in Riksmaten adolescents 2016-17 (12 E%), whereas the absolute intake was lower in the Riksmaten survey (59 g/day) (Wanselius et al., 2019). Sugar/sweets was the major contributor to per capita intake of free sugars (43%), followed by beverages (14%), pastries (11%), and fruits (11%). No time-trend was assessed due to the uncertainties in the estimations of free sugars, but similar intake was estimated in the Market Basket 2015 (80-85 g/day of added sugars (Swedish Food Agency, 2017)). It is reasonable to compare added and free sugars as there were only minor differences in the estimated per capita intake of added and free sugars in the Market Basket 2022 (<2 g/day) (data not shown).

Dietary fibres

Estimated per capita intake of dietary fibres was 45 g/day (Table 10), corresponding to 3 E% (Table 8). In terms of per MJ, the per capita intake was 3.7 g/MJ/day. This was about 50% higher than the intakes reported in the Riksmaten surveys (2.5 g/MJ/day (Amcoff et al., 2012) and 2.1 g/MJ/day (Warensjö Lemming et al., 2018a)). However, even though the same chemical analysis (AOAC 2009.01) is used in the Market Basket 2022 and new analyses of foods in the Swedish Food Agency´s food composition database, the fibre content in many food items in the food composition database are still based on the older method (AOAC 985.29). AOAC 2009.01 includes determination of non-available oligosaccharides, which are not included in AOAC 985.29. The latter method therefore underestimates the fibre content, and subsequently also the intake. The differences between the Market Basket 2022 and the Riksmaten surveys are hence probably a consequence of different chemical analytical methods. To some extent, not considering food waste in the Market Basket 2022 may also contribute to its higher fibre intake. Change of chemical analysis also explain the increase in dietary fibre intake in the present market basket study compared to previous (Figure 7), and it is important to point out that this probably is not a true increase in per capita intake. The largest contributors to the per capita intake were cereal products (32%) and potatoes (32%) (Figure 5). Of the fibre intake, 87% was HMWDF and 13% was LMWDF. Potatoes provided most (35%) to the HMWDF intake (including resistant starch), followed by cereal products (30%) (Figure 5). Cereal products provided a major part of LMWDF (50%), followed by vegetables (16%) (Figure 5).

Whole grain content was estimated for cereal products and pastries based on product information (see section 8.2.1). Estimated per capita intake of whole grains in the Market Basket 2022 was 39 g/day (38 g from cereal products and 1.5 g from pastries). This was in line with the whole grain intake in Riksmaten adults 2010-11 (42 g/day, (Amcoff et al., 2012)). Intake among adolescents was little lower (30 g/day, (Warensjö Lemming et al., 2018b)).

Table 8. Mean daily intake of proteins and energy intake per macronutrient from food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (g/person/day) Protein	Energy intake (kJ/person/day) Protein	Fat	Carbohydrates	Fibres	Energy
Cereal products	226		24	415	301	2173	116	3005
Pastries	55		3.9	67	322	489	15	892
		LB				35	3.6	1465
Meat	194	HB	34	582	837	40	6.7	1466
		UB				44	10	1467
		LB				39	0	494
Processed meat[1]	48	HB	6.0	102	350	44	0	496
		UB				44	2.3	496
		LB				1.8	0.20	57
Lean fish	15	HB	2.5	42	13	2.7	0.36	58
		UB				3.0	0.76	58
		LB					1.4	
Fatty fish	18	HB	3.2	54	95	14	1.5	165
		UB					1.6	
Meat substitutes	3		0.5	7.9	12	2.9	1.3	24
Lean dairy prod.	248		8.6	146	177	219	0*	541
Fatty dairy prod.	70		13	213	653	59	0*	925
Plant-based drinks	13		0.19	3.3	12	16	0.69	32
Eggs	29		3.6	62	106	4.2	0*	172
Fats and oils	55		0.28	4.7	1369	29	0*	1402
Vegetables	245		3.6	61	35	231	48	374
Fruits	215		3.7	63	214	548	45	870
Potatoes	142		3.0	50	99	254	113	517
Sugar and sweets	74		2.9	49	285	890	10	1234
		LB				218		218
Beverages	262	HB	0*	0*	0*	223	0*	223
		UB				223		223
		LB				**5183**	**354**	**11892**
Total		**HB**	**107**[2]	**1820**	**4529**	**5193**	**357**	**11898**
		UB				**5198**	**360**	**11899**

Food group	Per capita consumption (g/person/day)		Per capita intake (g/person/day) Protein	Energy intake (kJ/person/day)				
				Protein	Fat	Carbohydrates	Fibres	Energy
Energy distribution				**15 E%**	**38 E%**	**44 E%**	**3.0 E%**	
Recommended range[3]			0.66 g/kg/d	10-20 E%	25-40 E%	45-60 E%[4]		9000/11300
Riksmaten adults[5]			81	17 E%	34 E%	44 E%	2.0 E%	8300
Riksmaten adolescents[6]			88	17 E%	35 E%	46 E%	1.6 E%	8900

0*, content was assumed to be logical zero and no analyses were performed. Macronutrients were not analysed in pizza/hand pies and coffee/tea.

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects).

[1] Processed meat is a subgroup of meat and its consumption is included in meat. The subgroup was therefore not included when calculating total per capita intake.

[2] Corresponding to 1.5 g/kg body weight/day if assuming a population mean body weight of 70 kg.

[3] Recommended intake range of macronutrients for adults according to the Nordic Nutrition Recommendations (Blomhoff et al., 2023).

[4] The recommendation includes fibres. Comparison with the Market Basket 2022 should therefore include per capita intake of fibres.

[5] Riksmaten adults 2010-11 (Amcoff et al., 2012).

[6] Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018a).

Table 9. Mean daily intake of total fat and fatty acids from food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (g/person/day)							
			Total fat	SFA	MUFA	PUFA	n-3 PUFA	18:3 n-3	n-6 PUFA	TFA
		LB		0.77		2.4	0.32		2.0	0.00
Cereal products	226	HB	8.1	0.77	2.8	2.4	0.32	0.32	2.0	0.00
		UB		0.88		2.5	0.38		2.1	0.04
		LB		3.2	3.8	1.3	0.24		1.0	0.02
Pastries	55	HB	8.7	3.2	3.8	1.3	0.24	0.24	1.0	0.03
		UB		3.3	3.9	1.4	0.31		1.1	0.06
		LB		9.0	10	1.9	0.17		1.6	0.31
Meat	194	HB	23	9.0	10	1.9	0.17	0.17	1.6	0.31
		UB		9.4	11	2.2	0.36		1.7	0.37
		LB		3.6	4.4	0.90	0.07		0.79	0.04
Processed meat[1]	48	HB	9.5	3.6	4.4	0.90	0.07	0.06	0.79	0.04
		UB		3.8	4.5	1.0	0.14		0.83	0.08
		LB					0.04			
Lean fish	15	HB	0.34	0.3	0.13	0.08	0.04	0.01	0.04	0.00
		UB					0.05			
		LB		0.39		0.71				0.02
Fatty fish	18	HB	2.6	0.39	1.2	0.71	0.41	0.10	0.29	0.02
		UB		0.43		0.72				0.03
		LB		0.06			0.01			
Meat substitutes	3	HB	0.31	0.06	0.11	0.08	0.01	0.01	0.06	0.00
		UB		0.07			0.02			
		LB				0.14	0.03		0.07	
Lean dairy prod.	248	HB	4.8	3.2	1.1	0.14	0.03	0.03	0.07	0.18
		UB				0.22	0.07		0.10	
		LB			4.3	0.54	0.07		0.29	0.72
Fatty dairy prod.	70	HB	18	12	4.3	0.54	0.07	0.07	0.29	0.72
		UB			4.4	0.82	0.22		0.39	0.74
		LB		0.03	0.17	0.10				
Plant-based drinks	13	HB	0.33	0.03	0.17	0.10	0.02	0.02	0.08	0.00
		UB		0.04	0.18	0.11				
		LB		0.73		0.48	0.06		0.43	0.00

Food group	Per capita consumption (g/person/day)		Per capita intake (g/person/day) Total fat	SFA	MUFA	PUFA	n-3 PUFA	18:3 n-3	n-6 PUFA	TFA
Eggs	29	HB	2.9	0.73	1.2	0.49	0.06	0.03	0.43	0.00
		UB		0.78		0.52	0.07		0.44	0.02
		LB			17	7.3	2.0		4.8	0.37
Fats and oils	55	HB	37	11	17	7.3	2.0	2.0	4.8	0.37
		UB			18	7.9	2.3		5.1	0.51
Vegetables	245		0.95							
		LB		0.78		1.2	0.12			0.00
Fruits	215	HB	5.8	0.78	3.4	1.2	0.12	0.12	1.1	0.00
		UB		0.88		1.3	0.17			0.03
		LB		0.48		0.61	0.03		0.58	0.00
Potatoes	142	HB	2.7	0.48	1.5	0.61	0.03	0.03	0.58	0.00
		UB		0.53		0.66	0.05		0.60	0.02
		LB		3.9		0.58	0.02		0.49	0.04
Sugar and sweets	74	HB	7.7	3.9	2.9	0.58	0.02	0.02	0.49	0.04
		UB		4.0		0.71	0.09		0.55	0.07
Beverages	262		0*							
		LB		**45**	**50**	**17**	**3.5**		**13**	**1.7**
Total		**HB**	**122**	**45**	**50**	**17**	**3.5**	**3.1**	**13**	**1.7**
		UB		**46**	**51**	**19**	**4.5**		**14**	**2.1**
% of total FA				**39%**	**44% (43-44)**	**15% (15-16)**	**3.1% (3.1-3.8)**	**2.8% (2.7-2.8)**	**11%**	**1.5% (1.5-1.7)**
Energy distribution (E%)			**38 E%**	**14 E%**	**16 E%**	**5.4 E% (5.4-6.0)**	**1.1 E% (1.1-1.4)**	**1.0 E%**	**4.0 E% (4.0-4.2)**	**0.5 E% (0.5-0.6)**
Recommended range[2]			20-40 E%	<10 E%	10-20 E%	5-10 E%	1 E%	0.5 E%	3 E%	As low as possible
Riksmaten adults[3]			34 E%	13 E%	13 E%	5.6 E%	1.2 E%		4.2 E%	
Riksmaten adolescents[4]			35 E%	14 E%	14 E%	4.7	1.0 E%	0.8 E%	3.6 E%	

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; TFA, trans fatty acids. LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects).

Fatty acids were not analysed in vegetables due to low total fat content (<0.5%). Fatty acids were not analysed in pizza/hand pies and coffee/tea.

[1] Processed meat is a subgroup of meat and its consumption is included in meat. The subgroup was therefore not included when calculating total per capita intake.

[2] Recommended intake range according to the Nordic Nutrition Recommendations 2023 for adults (Blomhoff et al., 2023).

[3] Riksmaten adults 2010-11 (Amcoff et al., 2012).

[4] Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b).

Table 10. Mean daily intake of carbohydrates from food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consump. (g/pers/day)		Per capita intake (g/person/day)												
			Total CHO	Glycaemic CHO	Starch	Total fibres	HMWDF[1]	LMWDF	Total sugars	Fru	Glu	Gal	Suc	Mal	Lac
		LB							11			0			0
Cereal products	226	HB	128	126	115	14	12	2.9	11	2.9	2.4	0	0.72	5.4	0
		UB							12			0.09			0.09
		LB										0			
Pastries	55	HB	29	28	18	1.8	1.4	0.37	11	1.2	1.2	0	7.4	0.52	0.33
		UB										0.02			
		LB	2.1	2.5	0.84	0.45	0.32	0.13	1.6			0			
Meat	194	HB	2.3	3.1	1.5	0.84	0.58	0.26	1.6	0.13	0.95	0	0.21	0.21	0.15
		UB	2.6	3.9	2.1	1.2	0.84	0.39	1.7			0.08			
		LB	2.3	2.2		0	0	0	0.60	0		0			0.02
Processed meat[2]	48	HB	2.6	2.3	1.6	0	0	0	0.61	0	0.35	0	0.18	0.05	0.03
		UB	2.6	2.3		0.29	0.19	0.10	0.65	0.02		0.02			0.03
		LB	0.11	0.33		0.03	0.03	0	0.03	0		0	0	0.02	0
Lean fish	15	HB	0.16	0.33	0.30	0.05	0.05	0	0.04	0	0.01	0	0	0.02	0
		UB	0.18	0.36		0.10	0.07	0.03	0.06	0.01		0.01	0.01	0.03	0.01
		LB	0.81	0.83	0	0.17	0.07		0.83			0		0	0
Fatty fish	18	HB	0.82	0.83	0	0.19	0.08	0.11	0.83	0.02	0.04	0	0.76	0	0
		UB	0.84	1.0	0.18	0.20	0.09		0.85			0.01		0.10	0.01
		LB							0.04						
Meat substitutes	3	HB	0.17	0.16	0.11	0.16	0.13	0.03	0.04	0.01	0	0	0.01	0.03	0
		UB							0.05						
		LB		12	0					0.07				0	
Lean dairy prod.	248	HB	13	12	0	0*	0*	0*	12	0.08	0.34	0.55	1.4	0	9.7
		UB		15	2.5					0.10				0.10	
		LB		0.65	0				0.65	0	0.01	0	0	0	
Fatty dairy prod.	70	HB	3.5	0.66	0	0*	0*	0*	0.66	0	0.02	0	0	0	0.64
		UB		1.5	0.70				0.78	0.03	0.03	0.03	0.03	0.03	
		LB		0.53	0.11				0.42			0			0
Plant-based drinks	13	HB	0.92	0.56	0.13	0.09	0.05	0.03	0.42	0.01	0.02	0	0.11	0.29	0
		UB		0.59	0.16				0.43			0.01			0.01

Food group	Per capita consump. (g/pers/day)		Per capita intake (g/person/day)												
			Total CHO	Glycaemic CHO	Starch	Total fibres	HMWDF[1]	LMWDF	Total sugars	Fru	Glu	Gal	Suc	Mal	Lac
Eggs		LB		0.09	0				0.09	0		0	0	0	0
	29	HB	0.25	0.09	0	0*	0*	0*	0.09	0	0.09	0	0	0	0
		UB		0.44	0.29				0.15	0.01		0.01	0.01	0.01	0.01
Fats and oils		LB		0.59	0				0.59			0		0	
	55	HB	1.7	0.59	0	0*	0*	0*	0.59	0.05	0.06	0	0.35	0	0.13
		UB		1.2	0.55				0.63			0.02		0.02	
Vegetables		LB		14	0				14			0	0		0
	245	HB	14	14	0	6.0	5.1	0.90	14	7.0	7.2	0	0	0.13	0
		UB		17	2.5				15			0.10	0.10		0.10
Fruits		LB		36	1.0							0	0	0.05	0
	215	HB	32	37	1.7	5.6	5.2	0.36	35	19	16	0	0	0.08	0
		UB		38	2.4							0.09	0.09	0.11	0.09
Potatoes		LB							1.3			0	0.11		0
	142	HB	15	21	20	14	14	0.52	1.3	0.44	0.43	0	0.13	0.32	0
		UB							1.5			0.06	0.15		0.06
Sugar and sweets		LB										0			
	74	HB	52	49	7.9	1.3	1.0	0.30	41	2.3	4.4	0	31	1.3	2.9
		UB										0.03			
Beverages		LB		12	0				12			0		0	0
	262	HB	13	12	0	0*	0*	0*	12	3.3	3.1	0	5.9	0	0
		UB		15	2.6				13			0.10		0.10	0.10
Total		**LB**	**305**	**305**	**163**	**44**		**5.6**	**143**			**0.55**	**47**	**8.2**	
		HB	**306**	**307**	**164**	**45**	**39**	**5.7**	**143**	**36**	**36**	**0.55**	**48**	**8.3**	**14**
		UB	**306**	**319**	**175**	**45**		**5.9**	**144**			**1.2**	**48**	**8.6**	
Riksmaten adults[3]			212			20			88				39		
Riksmaten adolescents[4]			242			18			104				46		

Per capita consump., per capita consumption; CHO, carbohydrates; HMWDF, high molecular weight dietary fibre; LMWDF, low molecular weight dietary fibre; fru, fructose; glu, glucose; gal, galactose; suc, sucrose; mal, maltose; lac, lactose. LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects).

Total carbohydrates were calculated by difference (i.e. 1000 - water - ash - protein - fat - fibre). Glycaemic carbohydrates were calculated by sum of starch and total sugars. Total sugars were calculated by sum of fructose, glucose, galactose, sucrose, maltose, and lactose.

0*, content was assumed to be logical zero and no analyses were performed. Macronutrients were not analysed in pizza/hand pies and coffee/tea.

[1] HMWDF include resistant starch.

[2] Processed meat is a subgroup of meat and its intake is included in meat. The subgroup was therefore not included when calculating total per capita intake.

[3] Riksmaten adults 2010-11 (Amcoff et al., 2012).

[4] Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b).

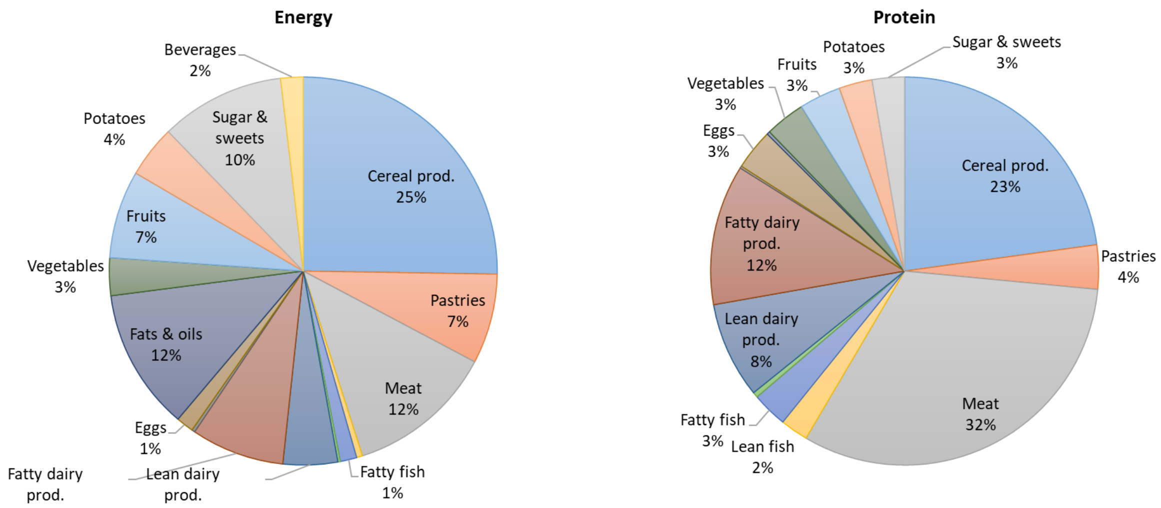

Figure 3. Percentage contribution to the per capita intake of energy and protein from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

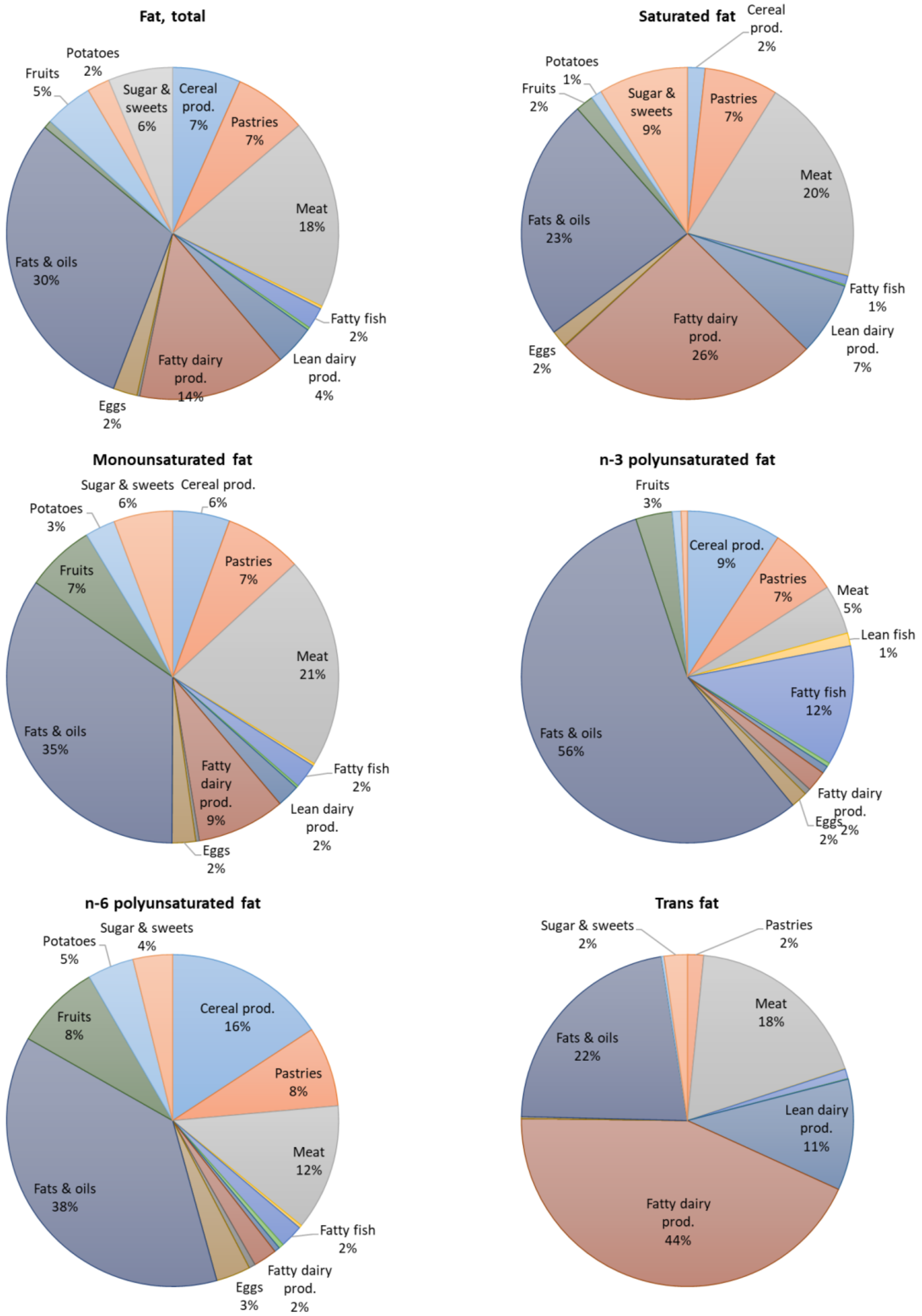

Figure 4. Percentage contribution to the per capita intake of fatty acids from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

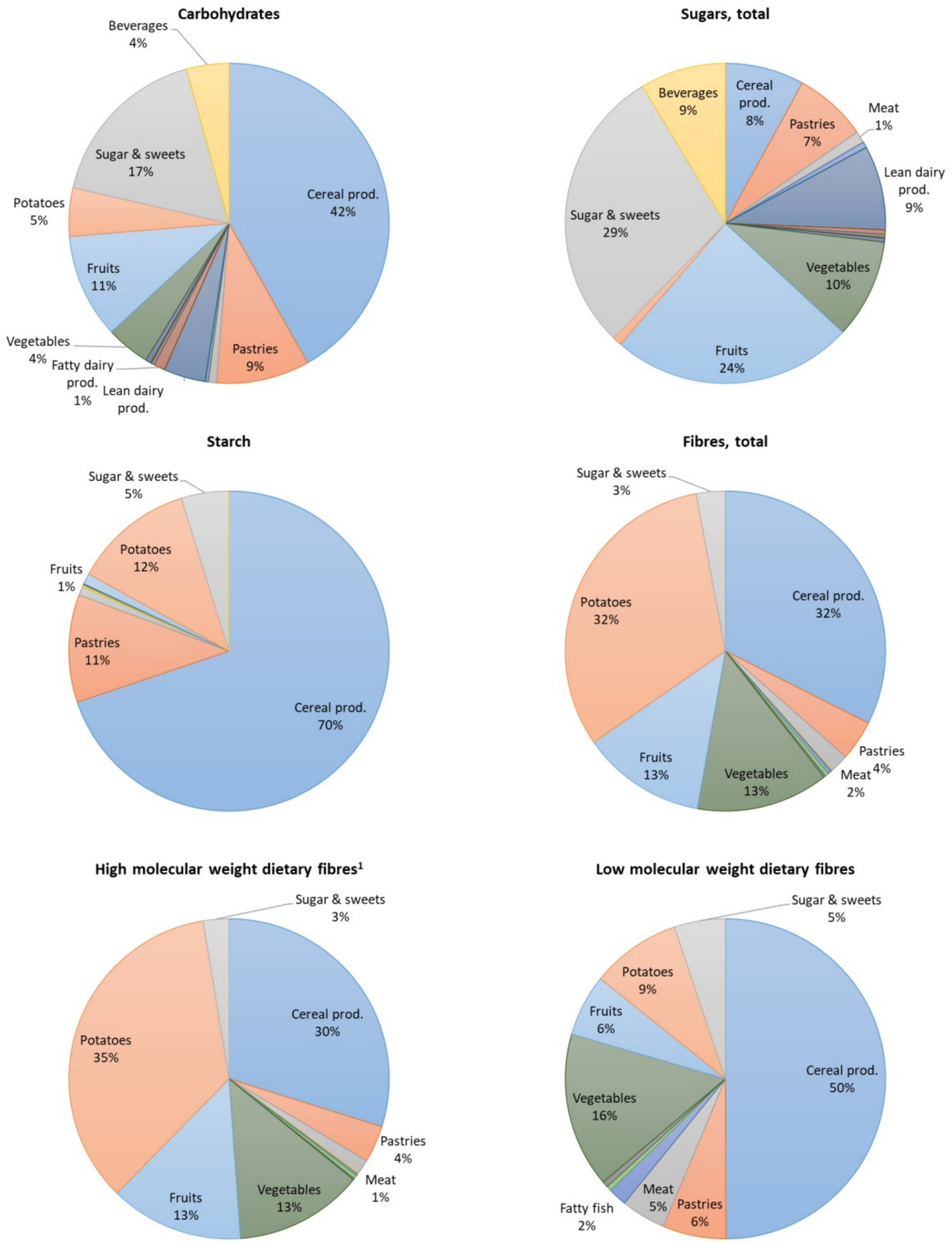

Figure 5. Percentage contribution to the per capita intake of carbohydrates and dietary fibres from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

[1] High molecular weight dietary fibres include resistant starch.

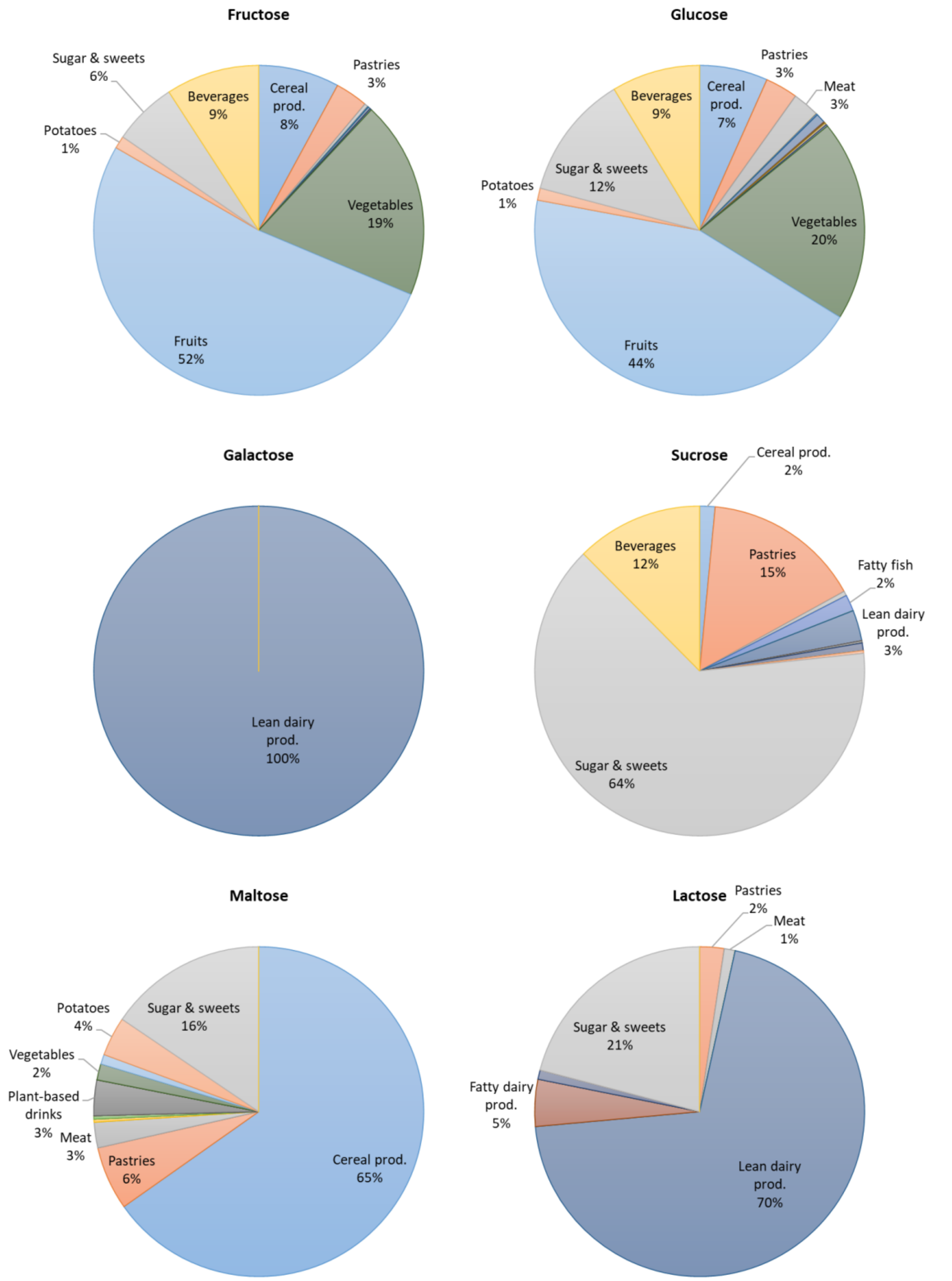

Figure 6. Percentage contribution to the per capita intake of sugars from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

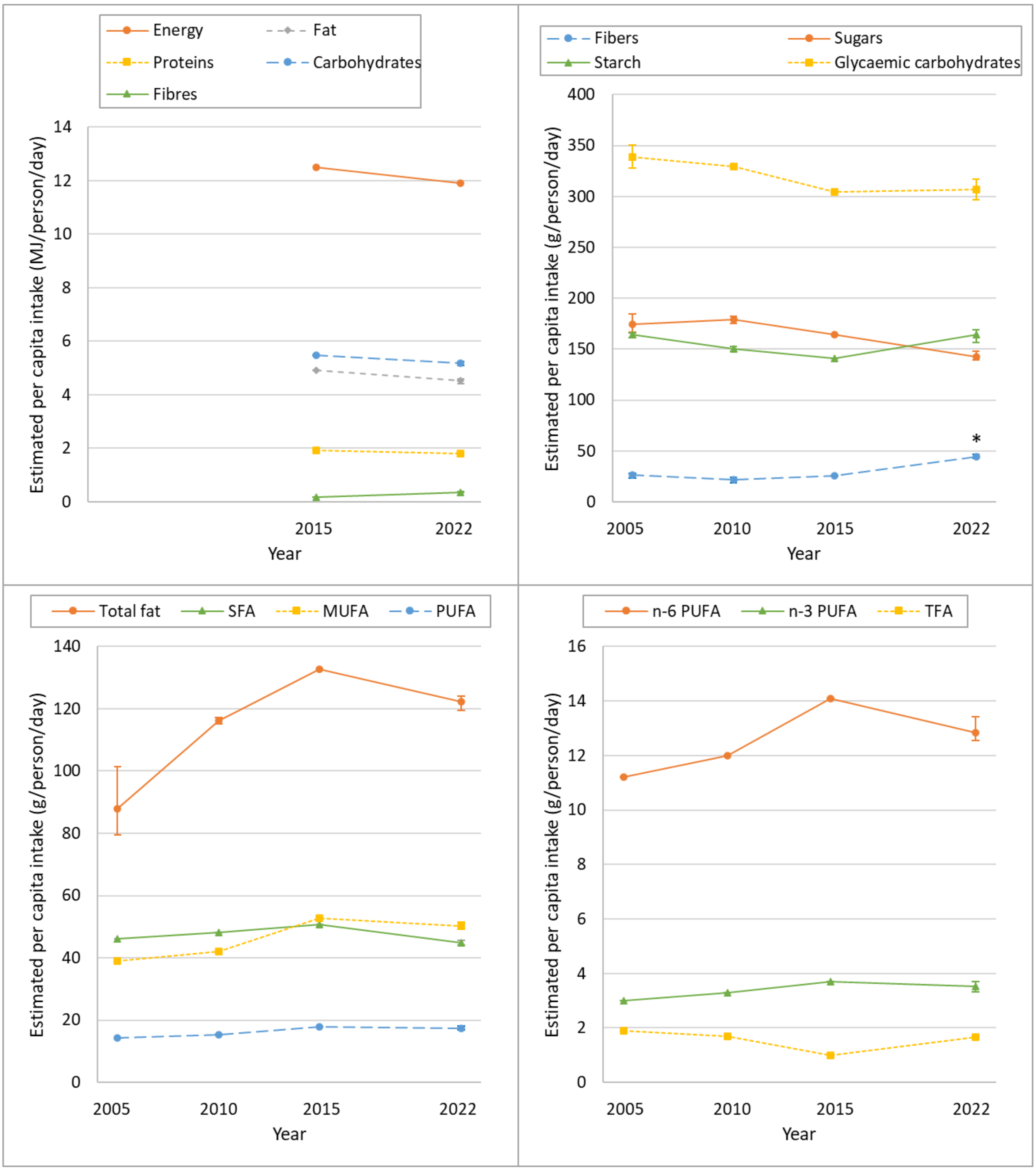

Figure 7. Estimated per capita intake of macronutrients, carbohydrates and fatty acids in market basket studies over time.

Note, that the per capita intake is a function of per capita consumption and compound concentrations in the food groups. Intake from coffee/tea was not included. Vertical lines indicate minimum and maximum values. Number of samples per food group was N=4 (2005), N=2 (2010), N=1 (2015), N=3 (2022).

* Note, another chemical method was used for analysis of dietary fibres in the Market Basket 2022 compared with previous, explaining the increase in per capita intake.

8.2.3 Risk and benefit assessments

Assessments of benefits or risks with the per capita intakes of macronutrients in the Market Basket 2022 was mainly evaluated using recommended intake ranges for adults as defined in the NNR (Blomhoff et al., 2023). These ranges are associated with reduced risk of chronic diseases while providing adequate intake of essential nutrients. The ranges are provided as guidance and not recommended intake (RI) (Blomhoff et al., 2023). Figure 8 shows the estimated per capita intakes of macronutrients in the Market Basket 2022 in relation to the reference intake ranges in the NNR.

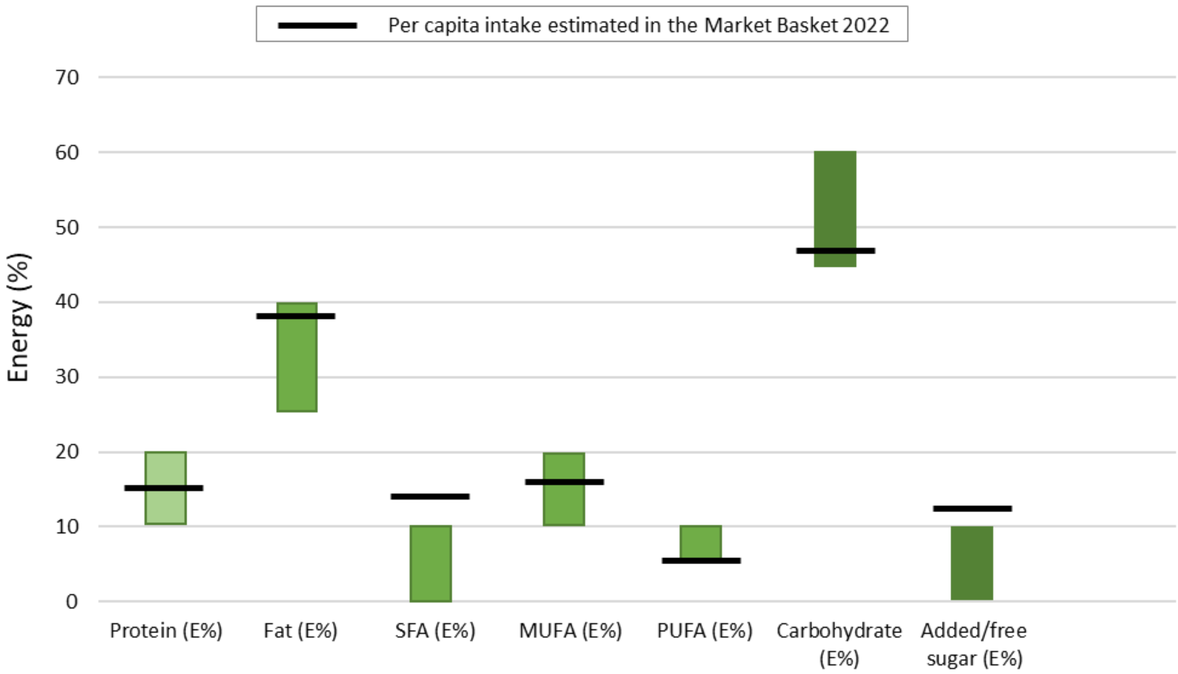

Figure 8. Estimated per capita intake in the Market Basket 2022 in relation to reference intake ranges of macronutrients (Blomhoff et al., 2023).

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids. Per capita intake of dietary fibres is included in carbohydrates in accordance with the Nordic Nutrition Recommendations.

Energy

Estimated per capita intake of energy in the Market Basket 2022 (12 MJ/day, Table 8) was higher than the reference values in the NNR (mean: 10 MJ/day, 9 MJ and 11 MJ for females and males, respectively (Blomhoff et al., 2023)). It is important to keep in mind that the market basket study investigates the energy supply and not energy intake in the population. It is therefore difficult to draw any conclusions regarding the energy intake in the Swedish population. Nevertheless, an intake of 12 MJ/day is in line with the refence value for a physically active young man and a large part of the population has reference energy intakes below 10 MJ/day (Blomhoff et al., 2023). Assuming a 15% overestimation in the Market Basket 2022, would mean an intake of 10 MJ/day.

The distribution of energy percentage between macronutrients (15 E% protein, 38 E% fat, 47 E% carbohydrates, Table 8 and Figure 8) were in agreement with the NNR, but fat intake was in the upper range and carbohydrates in the lower range. Energy from alcohol was not included in the Market Basket 2022.

Protein

Protein provides amino acids for protein synthesis in the body, essential for building of cells, production of enzymes and hormones. Proteins also provide energy. There are 20 amino acids, whereof 9 cannot be produced in the body and are essential. The energy percentage of protein (15 E%, Table 8) was in agreement with 10-20 E% as recommended by the NNR (Blomhoff et al., 2023). Average requirement (AR) and recommended intake (RI) are set for protein based on nitrogen balance. The protein intake (1.5 g/kg/day, Table 8) was about double as high as average requirement (AR) (0.66 g/kg/day) and recommended intake (RI) (0.83 g/kg/day) according to the NNR (Blomhoff et al., 2023), if assuming a mean body weight of 70 kg (see section 7.1.3).

Fat and fatty acids

Fat is needed as a source of energy and for absorption of the fat-soluble vitamins A, D, E, and K. Fats are mainly present in food in the form of triglycerides. Triglycerides are composed of a glycerol molecule and three fatty acids. There are two essential fatty acids, which cannot be produced in the body and must therefore be provided via food. These are linoleic acid (18:2 n-6) and alpha-linolenic acid (18:3 n-3). Partial replacement of SFA with n-6 PUFA improves plasma lipid profile and decreases the risk of cardiovascular disease (Blomhoff et al., 2023). Long-chain n-3 PUFA have also beneficial effects on plasma triglycerides and risk of cardiovascular disease (Blomhoff et al., 2023). TFA impairs blood lipid profile and is positively associated with cardiovascular disease and total mortality (Retterstol and Rosqvist, 2024).

Estimated mean energy percentage of total fat intake in the Swedish population (38 E%, Table 8) was within the recommendation (25-40 E%) (Blomhoff et al., 2023). The estimated per capita intake of SFA (14 E%) was higher than the recommended intake range of less than 10 E% (Blomhoff et al., 2023), which also agrees with results from the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). Intakes of MUFA (16 E%) and PUFA (5 E%) were in accordance with recommended intake ranges (10-20 E% and 5-10 E%, respectively). Recommended intakes of at least 3 E% n-6 PUFA, 1 E% n-3 PUFA and 0.5 E% α-linolenic acid (18:3 n-3) were also reached by the estimated per capita intakes (4 E%, 1 E%, and 1 E%) (Becker et al., 2011). The NNR recommends TFA to be as low as possible. The estimated intake in the Market Basket 2022 was 0.5 E%.

Carbohydrates and fibres

Carbohydrates

Carbohydrates are a major source of energy. There are four main groups of carbohydrates as defined chemically: monosaccharides (glucose, fructose, and galactose), disaccharides (sucrose, lactose, and maltose), oligosaccharides, and polysaccharides. “Sugars” refer to monosaccharides and disaccharides. The per capita intake of carbohydrates in the Market Basket 2022 was 47 E%, if also including fibres (Table 8), and hence within the lower range of the NNR recommendations (45-60 E%) (Blomhoff et al., 2023).

The quality of carbohydrates is affected by the proportion of added or free sugar and dietary fibre content. Added/free sugars are associated with risk for chronic metabolic diseases, dental caries, and leave less room for healthy food which provides micronutrients. It is therefore recommended that the intake of added and free sugars should be below 10 E%, and preferentially lower (Blomhoff et al., 2023). The estimated population mean intake in the Market Basket 2022 was higher (12 E%), indicating a need for an overall reduced intake in the Swedish population. This is also in line with results from Swedish adolescents (Wanselius et al., 2019).

Dietary fibres

A high intake of fibres is associated with lower all-cause mortality, as well as lower risk of coronary heart disease, colorectal cancer, stroke and type 2 diabetes. Fibres may also increase nutrient intake and satiety. The recommended intake of fibres is 3-3.5 g/MJ/day (Blomhoff et al., 2023). A per capita intake above the recommendation was observed in the Market Basket 2022 (3.7 g/MJ/day), indicating a sufficient mean intake of fibres in the population. However, because different fibre analyses include different types of fibres, this comparison should be interpreted with caution. The estimated intake in the Market Basket 2022 was based on a method giving higher fibre concentrations, whereas older fibre methods measuring lower content can be assumed in many of the scientific studies used in the evaluation in the NNR. In comparison, previous estimations of the per capita intake and intakes in adults and adolescents were 2-2.5 g/MJ/day (Swedish Food Agency, 2017, Warensjö Lemming et al., 2018a).

Whole grains lower the risks of cardiovascular disease, colorectal cancer, type 2 diabetes and premature mortality (Blomhoff et al., 2023). The estimated per capita intake of whole grains in the Market Basket 2022 (39 g/day) was much lower than the recommendation of at least 90 g/day (Blomhoff et al., 2023).

8.2.4 Conclusion

The Market Basket 2022 only estimates the energy supply and not the energy intake in the population (i.e. consumption data is used instead of information from consumers about their actual food consumption). This limits the interpretation of energy intake. The distribution of energy percentage between macronutrients agreed with recommendations.

SFA was higher than recommendations whereas MUFA, PUFA, n-3 and n-6 PUFA were in line with the recommendations. Even though the estimated per capita intake of TFA was slightly higher in the Market Basket 2022 compared with the Market Basket 2015, there was no overall time trend and the estimated intake was low (e.g. 0.5 E%).

Estimated mean intake of free sugars in the population are higher than the recommendations. A higher mean fibre intake compared with the previous market basket was observed, but this result is difficult to interpret considering differences in assessed fibre concentrations between different chemical analysis methods. Estimated per capita intake of whole grains based on product information indicated a mean whole grain intake less than half of what is recommended.

8.3 Vitamins

Vitamins are a group of varied organic compounds essential in human diet to maintain normal metabolism and function of several chemical reactions in the body. All four fat-soluble vitamins (A, D, E, and K) and three water-soluble vitamins (thiamin, riboflavin and folate) were determined in the Market Basket 2022. The fat-soluble vitamins were analysed at the Swedish Food Agency, and the water-soluble vitamins were analysed at Eurofins Vitamin Testing in Denmark. All laboratories were accredited. Briefly, retinols and vitamin D were determined using HPLC-ultraviolet. Tocopherols/tocotrienols and vitamin K were analysed by HPLC-fluorescence detector, and carotenoids were determined by HPLC-diode-array detection. Thiamin and riboflavin concentrations were analysed using HPLC. Folate was determined by a microbiological assay. Measurement uncertainties, and LOQs are shown in Table 11. The chemical analyses are described in more detail in Appendix 4 (section A 4.2).

Vitamin A content was determined by retinol and carotenoids in terms of retinol equivalents (RE) and calculated as follows: RE = (µg trans-all-retinol + β-carotene/6 + (α-carotene + β-cryptoxanthin)/12) (EFSA, 2015b, Blomhoff et al., 2023). Vitamin D content was determined by vitamin D3 concentration (cholecalciferol), with exception of plant-based drinks which were determined by vitamins D_2 (ergocalciferol). Vitamin K content was calculated as the sum of vitamins K1 (phylloquinone) and K2 (menaquinone-4).

Table 11. Limits of quantification (LOQ) and measurement uncertainty for methods used for determination of vitamins in the Market Basket 2022.

Substance	LOQ (µg/kg)	Measurement uncertainty (%)
Vitamin A - retinol	60	± 9-18
Vitamin A – carotenoids	50	± 12-18
Vitamin D	3	± 7-14
Vitamin E	130	± 8-18
Vitamin K	10	± 9-16
Thiamin	180	± 16
Riboflavin	100	± 16
Folate	50	± 30

1 g/kg = 0.1 g/100 g.

8.3.1 Concentrations in food groups

Concentrations of vitamin A (retinol, carotenoids), vitamin D (cholecalciferol, ergocalciferol), vitamin E (α-tocopherols), vitamin K (K1, K2), thiamin (vitamin B1), riboflavin (vitamin B2), and folate (vitamin B9) in the different food groups in the Market Basket 2022 are presented in Table 12. Concentrations of carotenoids (lutein, lycopene, xeaxanthine) and tocopherols (β-, δ-, γ-tocopherol and α-, β-, δ-, γ-tocotrienol) not included in the calculations of vitamin A and vitamin E, respectively, are presented in Appendix 5 (section A 5.2).

EU regulation for nutrient claims (Regulation (EC) No 1924/2006) defines a significant amount of a vitamin in relation to recommended daily allowance values (RDA) described in EU regulation 1169/2011 (Regulation (EU) No 1169/2011). Significant amount for a food product is considered to be 15% of RDA per 100g or 100 ml, and for a beverage product 7.5% of RDA per 100 ml. The purpose of the regulation is to harmonise the provisions for nutrition and health claims for commercial communication of individual products. An evaluation of the nutrient content of the food groups in the Market Basket 2022 was done using the EU regulation 1169/2011 (Regulation (EU) No 1169/2011). It should however only be considered as an indication because it is on food group level.

Vitamin A

The highest amounts of retinol were found in the food groups fats/oils, fatty dairy products, and meat, while the highest amounts of carotenoids were found in the group for vegetables, and fats/oils (Table 12). The RE in these four food groups corresponded to the criterion for significant amount, i.e. more than 15% of the nutrient reference value for retinol (800 µg/100 g) (Regulation (EU) No 1169/2011).

Vitamin D

The highest contents of vitamin D were found in fatty fish and fats/oils (Table 12). Fatty fish, lean dairy products, plant-based drinks, eggs and fats/oils had vitamin D contents that fulfilled the criterion for significant amount, i.e. content higher than 15% of the nutrient reference value (5 µg/100 g) (Regulation (EU) No 1169/2011).

Vitamin E

The highest concentration of vitamin E (α-tocopherol) was found in fats/oils, followed by eggs, and fatty fish (Table 12). Pastries, fatty fish, meat substitutes, eggs and fats/oils had vitamin E content higher than 15% of the nutrient reference value (12 mg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Vitamin K

Vitamin K was expressed as the sum of vitamin K1 (phylloquinone) and vitamin K2 (menaquinone-4). The highest concentrations of vitamin K were found in fats/oils, vegetables, and eggs (Table 12). The contents in the food groups meat, eggs, fats/oils, and vegetables were higher than 15% of the nutrient reference value for vitamin K (75 µg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Thiamin (vitamin B1)

High concentrations of thiamin were found in meat, meat substitutes, and cereal products (Table 12). The thiamin contents of the food groups meat and meat substitutes corresponded to more than 15% of the nutrient reference value (1.1 mg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Riboflavin (vitamin B2)

Eggs had the highest concentrations of riboflavin, followed by plant-based drinks and fatty dairy products (Table 12). These three food groups had riboflavin content of more than 15% of the nutrient reference value (1.4 mg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Folate (vitamin B9)

The highest concentrations of folate were found in eggs, meat substitutes, and cereal products (Table 12). The folate contents of eggs and meat substitutes corresponded to more than 15% of the nutrient reference value (200 µg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Table 12. Concentrations of vitamins[1] in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
Vitamin A[2] (RE/kg)	Mean	0	228	1222	0	83	35	185	2469	7.7	588	5379	2227	154	0	184	0
	Min	<LOQ	108	977	<LOQ	65	17	167	2375	4.2	563	5180	2115	104	<LOQ	159	<LOQ
	Median	<LOQ	189	1120	<LOQ	69	44	186	2487	4.2	568	5290	2256	145	<LOQ	193	<LOQ
	Max	<LOQ	386	1570	<LOQ	116	45	201	2546	15	631	5667	2310	213	<LOQ	200	<LOQ
All-trans-retinol (µg/kg)	Mean	0	102	1222	0	83	0	170	2330	0	581	4983	0	0	0	166	0
	Min	<60	60	977	<60	65	<60	155	2240	<60	556	4780	<60	<60	<60	147	<60
	Median	<60	103	1120	<60	69	<60	171	2340	<60	563	4920	<60	<60	<60	171	<60
	Max	<60	144	1570	<60	116	<60	184	2410	<60	624	5250	<60	<60	<60	180	<60
β-carotene (µg/kg)	Mean	0	676	0*	0*	0*	211	87	835	46	0	2373	11100	476	0	109	0*
	Min	<50	273				101	70	812	<50	<50	2220	10800	296	<50	72	
	Median	<50	504				263	88	815	<50	<50	2400	11200	564	<50	80	
	Max	<50	1250				269	103	879	88	<50	2500	11300	568	<50	176	
α-carotene (µg/kg)	Mean	0	153	0*	0*	0*	0	0	0	0	0	0	4413	127	0	0	0*
	Min	<50	<50				<50	<50	<50	<50	<50	<50	3660	109	<50	<50	
	Median	<50	<50				<50	<50	<50	<50	<50	<50	4310	127	<50	<50	
	Max	<50	408				<50	<50	<50	<50	<50	<50	5270	146	<50	<50	
β-cryptoxanthin (µg/kg)	Mean	0	0	0*	0*	0*	0	0	0	0	79	0	109	768	0	0	0*
	Min	<50	<50				<50	<50	<50	<50	64	<50	53	485	<50	<50	
	Median	<50	<50				<50	<50	<50	<50	86	<50	114	548	<50	<50	
	Max	<50	<50				<50	<50	<50	<50	87	<50	159	1270	<50	<50	
Vitamin D[3] (µg/kg)	Mean	0	0	0	4.7	73	0	11	0	9.8	14	64	0*	0*	0*	0	0*
	Min	<3	<3	<3	3.7	61	<3	10	<3	7.8	13	55				<3	
	Median	<3	<3	<3	4.1	71	<3	11	<3	10	14	59				<3	
	Max	<3	<3	<3	6.2	87	<3	11	<3	11	14	79				<3	
Vitamin E (α-tocopherol)	Mean	9.0	31	7.6	18	40	20	0.6	6.3	8.2	53	134	5.7	8.6	3.7	10	4.3
	Min	7.1	30	4.5	16	37	8.8	0.47	6.2	7.3	53	131	5.2	6.8	3.6	9.3	3.5

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
(mg/kg)	Median	8.6	30	7.3	18	41	26	0.58	6.2	8.4	53	133	5.6	9.4	3.8	9.5	4.1
	Max	11	33	11	19	41	26	0.88	6.5	8.8	54	138	6.2	9.6	3.8	12	5.3
Vitamin K[4] (µg/kg)	Mean	19	62	156	8.2	57	88	0	103	40	222	558	243	39	23	19	0*
	Min	16	52	149	5.0	51	49	<LOQ	97	31	214	536	220	38	18	18	
	Median	16	58	150	5.0	53	101	<LOQ	102	34	224	550	247	39	19	20	
	Max	25	76	170	15	68	115	<LOQ	110	55	227	590	262	41	31	21	
Vitamin K1 (µg/kg)	Mean	19	62	17	8.2	34	88	0	22	40	0	502	243	39	23	19	0*
	Min	16	52	11	<10	27	49	<10	21	31	<10	486	220	38	18	18	
	Median	16	58	17	<10	35	101	<10	22	34	<10	486	247	39	19	20	
	Max	25	76	22	15	41	115	<10	24	55	<10	535	262	41	31	21	
Vitamin K2 (µg/kg)	Mean	0	0	139	0	23	0	0	81	0	222	56	0	0	0	0	0*
	Min	<10	<10	131	<10	18	<10	<10	75	<10	214	51	<10	<10	<10	<10	
	Median	<10	<10	139	<10	23	<10	<10	81	<10	224	54	<10	<10	<10	<10	
	Max	<10	<10	148	<10	27	<10	<10	86	<10	227	64	<10	<10	<10	<10	
Thiamin (vitamin B1) (mg/kg)	Mean	1.3	0.78	2.9	0.35	1.2	1.7	0	0	0.23	0.66	0	0.42	0.30	0.52	0.17	0
	Min	1.2	0.67	2.8	0.30	1.1	1.3	<0.18	<0.18	0.19	0.66	<0.18	0.35	0.23	0.47	<0.18	<0.18
	Median	1.3	0.74	2.9	0.32	1.1	1.7	<0.18	<0.18	0.24	0.66	<0.18	0.42	0.26	0.52	0.19	<0.18
	Max	1.3	0.93	3.1	0.44	1.3	2.1	<0.18	<0.18	0.27	0.67	<0.18	0.48	0.41	0.58	0.23	<0.18
Riboflavin (vitamin B2) (mg/kg)	Mean	0.66	0.84	1.8	0.60	1.0	0.97	1.7	2.3	2.4	4.5	0.23	0.37	0.42	0.26	1.5	0
	Min	0.56	0.79	1.6	0.53	0.94	0.83	1.7	2.3	2.3	4.4	0.17	0.32	0.39	0.20	1.3	<0.1
	Median	0.70	0.81	1.8	0.61	0.97	0.87	1.7	2.4	2.4	4.6	0.24	0.39	0.41	0.25	1.3	<0.1
	Max	0.71	0.91	1.9	0.64	1.2	1.2	1.8	2.4	2.6	4.6	0.27	0.40	0.46	0.33	1.9	<0.1
Folate (vitamin B9) (µg/kg)	Mean	253	165	35	75	35	377	69	125	67	827	0*	72	59	97	87	0
	Min	229	151	<50	73	<50	339	39	112	<50	795		64	54	79	82	<50
	Median	248	154	<50	74	<50	342	84	130	88	819		71	56	105	89	<50
	Max	281	191	54	78	55	451	85	132	89	867		80	66	106	89	<50

1 g/kg = 0.1 g/100 g. No analyses were performed in the food groups subgroup pizza/hand pies, and coffee/tea.

0*, content was assumed to be logical zero and no analyses were performed.

< indicates a value below limit of quantification (LOQ). When calculating means as well as concentrations of vitamin A, D and K, hybrid bound approach was used. This means that medium bound (0.5*LOQ) was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a vitamin below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

[1] Concentrations of other carotenoids (lutein, lycopene, zeaxanthin) and tocopherols/tocotrienols (β-, δ-, γ-tocopherol and α-, β-, δ-, γ-tocotrienol) were also analysed. These results are presented in Appendix 5 (section A 5.2).

[2] Vitamin A concentrations were expressed as retinol equivalents (RE) and calculated as the sum of (µg trans-all-retinol + β-carotene/6 + (α-carotene + β-cryptoxanthin)/12) (EFSA, 2015b, Blomhoff et al., 2023).

[3] Vitamin D concentrations were determined by vitamin D_3. With exception of plant-based drinks, for which vitamin D_2 concentrations were used (vitamin D_3<3 µg/kg for all three samples with plant-based drinks).

[4] Vitamin K concentrations were calculated as the sum of vitamins K1 and K2.

8.3.2 Exposure estimations and time trends

Estimated mean intakes of vitamin A, D, E, K, thiamin, riboflavin and folate in the Swedish population (per capita intakes) are shown in Table 13. The proportional contribution of each food group to the per capita intakes of fat-soluble and water-soluble vitamins are presented in Figure 9 and Figure 10, respectively. The food group fats and oils was an important contributor to per capita intake for the four fat-soluble vitamins, but vegetables, lean dairy products and meat were also important contributors. Sources for the per capita intake of water-soluble vitamins were more varying, but were in general meat, cereal products, and lean dairy products.

Figure 11 illustrates changes in estimated per capita intake of vitamins in market basket studies. Vitamin D was the only vitamin with more than two observations, and hence an available time trend. For vitamin E, vitamin K and folate, per capita intakes were available for the Market Basket 2015. Vitamin A, thiamin and riboflavin have not been determined in previous market basket studies and were therefore not included in the figure.

Vitamin A

The per capita intake of vitamin A (1400 µg RE/day, Table 13) was almost double the intake in the Riksmaten surveys (660-820 µg/day (Amcoff et al., 2012, Warensjö Lemming et al., 2018b)). Vitamin A in the Swedish Food Composition Database is partly estimated by retinol activity equivalents (1 RAE = 1 µg all-retinol + β-carotene/12 + (α-carotene+β-cryptoxanthin)/24)) instead of retinol equivalents used in the present study (1 RE = µg all-retinol + β-carotene/6 + (α-carotene+β-cryptoxanthin)/12)). This may partly explain the higher intake in the Market Basket 2022, but per capita intake was still higher even if estimated by RAE (1100 µg RAE). Vegetables (40%), fats/oils (22%), and meat (17%) contributed the most to the per capita intake of vitamin A (Figure 9). Vitamin A has not been determined in previous market basket studies.

Vitamin D

The estimated per capita intake of vitamin D (8.2 µg/day, Table 13) was a bit higher than the intake in Riksmaten adults 2010-11 (7.0 µg/day (Amcoff et al., 2012)) and Riksmaten adolescents 2016-17 (5.9 µg/day (Warensjö Lemming et al., 2018b)). The major contributors to the per capita intake of vitamin D were fats/oils (43%), lean dairy products (33%) and fatty fish (16%) (Figure 9). Time trend of per capita intake of vitamin D is shown in Figure 11. The per capita intake of vitamin D increased with approximately 30% since it was first measured in 2010 (6.1 µg/day (Swedish Food Agency, 2012)) and with 17% from 2015 (7.0 µg/day (Swedish Food Agency, 2017)). The increase from the Market Basket 2015 was mainly driven by a higher vitamin D content in lean dairy products (from 0.3 µg/100 g to 1.1 µg/100 g) and is explained by the implementation of the new fortification policy in 2018 (Swedish Food Agency, 2018, Itkonen et al., 2021). This legislation meant that milk ≤ 1.5% fat, margarine, and fat blends were fortified at higher levels and that more products (all milk, yoghurt and sour milk products with fat <3%, lactose-free products, vegetable-based alternatives and fat blends) were fortified. The increase before 2015 was mainly driven by higher concentrations in the food group fats and oils and could be due to that some manufacturer started with fortification of fats prior the new legislation was entered into force. Interestingly, the per capita intake of vitamin D from dairy products increased despite that the consumption of dairy products decreased during the same period.

Vitamin E

The per capita intake of vitamin E (α-tocopherol) was 22 mg/day (Table 13). This was almost twice as high as the intakes in the Riksmaten surveys (12 mg/day (Amcoff et al., 2012, Warensjö Lemming et al., 2018b)). Fats/oils (34%) was the main contributor to the intake of vitamin E, followed by cereal products (9%), fruits (9%), and pastries (8%) (Figure 9). Vitamin E was about 24% higher in the Market Basket 2022 compared to in 2015 (22 mg/day vs 17 mg/day). The higher per capita intake in 2022 did not seem to be attributed to a specific food group but was rather general over all food groups.

Vitamin K

Estimated per capita intake of vitamin K was 160 µg/day (Table 13). No comparisons were made with the Riksmaten surveys. These surveys do not include vitamin K intake because it is not fully covered in the Swedish Food Composition Database. The per capita intake was similar as estimated in the previous market basket study in 2015 (approximately 180 µg/day (Swedish Food Agency, 2017)). There were no major differences in vitamin K content of the food groups between the studies. The only exceptions were a reduction of vitamin K content in the food group sugar/sweets (from 7 to 2 µg/100 g) and increased content in the food group fats/oils (from 47 to 56 µg/100 g), which was explained by that fatty dressings was included in sugar/sweets in the Market Basket 2015 and fats/oils in the Market Basket 2022. Vegetables (38%), fats/oils (20%), and meat (19%) comprised most of the per capita intake of vitamin K (Figure 9).

Thiamin (vitamin B1)

The per capita intake of thiamin (1.2 mg/day, Table 13), which was equal to the intakes estimated in Riksmaten adults 2010-11 (12 mg/day (Amcoff et al., 2012)), and Riksmaten adolescents 2016-17 (13 mg/day (Warensjö Lemming et al., 2018b)). The main contributors to the per capita intake of thiamin were meat (47%), cereal products (24%), and vegetables (9%) (Figure 10). Thiamin has not been determined in previous market basket studies.

Riboflavin (vitamin B2)

The per capita intake of riboflavin was 1.7 mg/day (Table 13), which was in line with the intakes observed in Riksmaten adults 2010-11 (1.5 mg/day (Amcoff et al., 2012)), and Riksmaten adolescents 2016-17 (1.6 mg/day (Warensjö Lemming et al., 2018b)). Lean dairy products (26%), meat (20%), and fatty dairy products (10%) contributed the most to the per capita intake of riboflavin (Figure 10). Riboflavin has not been determined in previous market basket studies.

Folate (vitamin B9)

The estimated per capita intake of folate (180 µg/day, Table 13) was lower than the intakes of 260 µg/day in the Rikmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). The per capita intake was similar as estimated in the previous market basket study in 2015 (205 µg/day), especially considering lower and upper bound estimations (173-194 µg/day). The intake in the Market Basket 2015 has been corrected due to an error in the calculation. The main contributor to the per capita intake of folate was cereal products (32%), followed by eggs (14%), vegetables (10%), and lean dairy products (10%) (Figure 10).

Table 13. Mean daily intake of vitamins from food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (per person/day)						
			Vit A (µg)	Vit D (µg)	Vit E (mg)	Vit K (µg)	Thiamin (mg)	Riboflavin (mg)	Folate (µg)
Cereal products	226	LB	0	0	2.0	4.3	0.29	0.15	57
		HB	0	0		4.3			
		UB	17	0.68		6.5			
Pastries	55	LB	12	0	1.7	3.4	0.04	0.05	9.1
		HB	13	0		3.4			
		UB	13	0.17		4.0			
Meat	194	LB	237	0	1.5	30	0.56	0.34	3.5
		HB		0					6.7
		UB		0.58					9.9
Lean fish	15	LB	0	0.07	0.27	0.07	0.01	0.01	1.1
		HB	0			0.12			
		UB	0.90			0.32			
Fatty fish	18	LB	1.5	1.3	0.72	1.0	0.02	0.02	0.33
		HB							0.63
		UB							0.93
Meat substitutes	3	LB	0.11	0	0.06	0.26	0.01	0	1.1
		HB	0.11	0		0.26			
		UB	0.31	0.01		0.29			
Lean dairy products	248	LB	46	2.7	0.16	0	0	0.43	17
		HB	46			0	0		
		UB	48			5.0	0.04		
Fatty dairy products	70	LB	173	0	0.44	7.2	0	0.16	8.7
		HB		0			0		
		UB		0.21			0.01		
Plant-based drinks	13	LB	0.06	0.13	0.11	0.52	0	0.03	0.77
		HB	0.10	0.13		0.52			0.87
		UB	1.0	0.17		0.65			0.98
Eggs	29	LB	17	0.40	1.5	6.4	0.02	0.13	24
		HB				6.4			

Food group	Per capita consumption (g/person/day)		Per capita intake (per person/day)						
			Vit A (µg)	Vit D (µg)	Vit E (mg)	Vit K (µg)	Thiamin (mg)	Riboflavin (mg)	Folate (µg)
		UB				6.7			
		LB					0		
Fats and oils	55	HB	296	3.5	7.4	31	0	0.01	0*
		UB					0.01		
		LB	546			60			
Vegetables	245	HB	546	0*	1.4	60	0.10	0.09	18
		UB	560			62			
		LB	33			8.4			
Fruits	215	HB	33	0*	1.8	8.4	0.06	0.09	13
		UB	46			11			
		LB	0			3.2			
Potatoes	142	HB	0	0*	0.53	3.2	0.07	0.04	14
		UB	11			4.7			
		LB		0		1.4			
Sugar and sweets	74	HB	14	0	0.75	1.4	0.01	0.11	6.4
		UB		0.22		2.2			
		LB	0				0	0	0
Beverages	262	HB	0	0*	1.1	0*	0	0	0
		UB	16				0.05	0.03	13.1
		LB	**1375**	**8.2**		**157**	**1.2**		**173**
Total		**HB**	**1375**	**8.2**	**22**	**157**	**1.2**	**1.7**	**177**
		UB	**1453**	**10**		**172**	**1.3**		**194**
Average requirement[1]			540/630	7.5	8/9	50/60	0.65/0.75	1.3	250
Riksmaten adults[2]			821	7.0	12		1.2	1.5	259
Riksmaten adolescents3			**657**	**5.9**	**12**		**1.3**	**1.6**	**263**

Macronutrients were not analysed in pizza/hand pies and coffee/tea. 0*, content was assumed to be logical zero and no analyses were performed.

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects).

[1] Average requirement according to the Nordic Nutrition Recommendations 2023 for females/males 25-70 years (Blomhoff et al., 2023).

[2] Riksmaten adults 2010-11 (Amcoff et al., 2012).

[3] Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b).

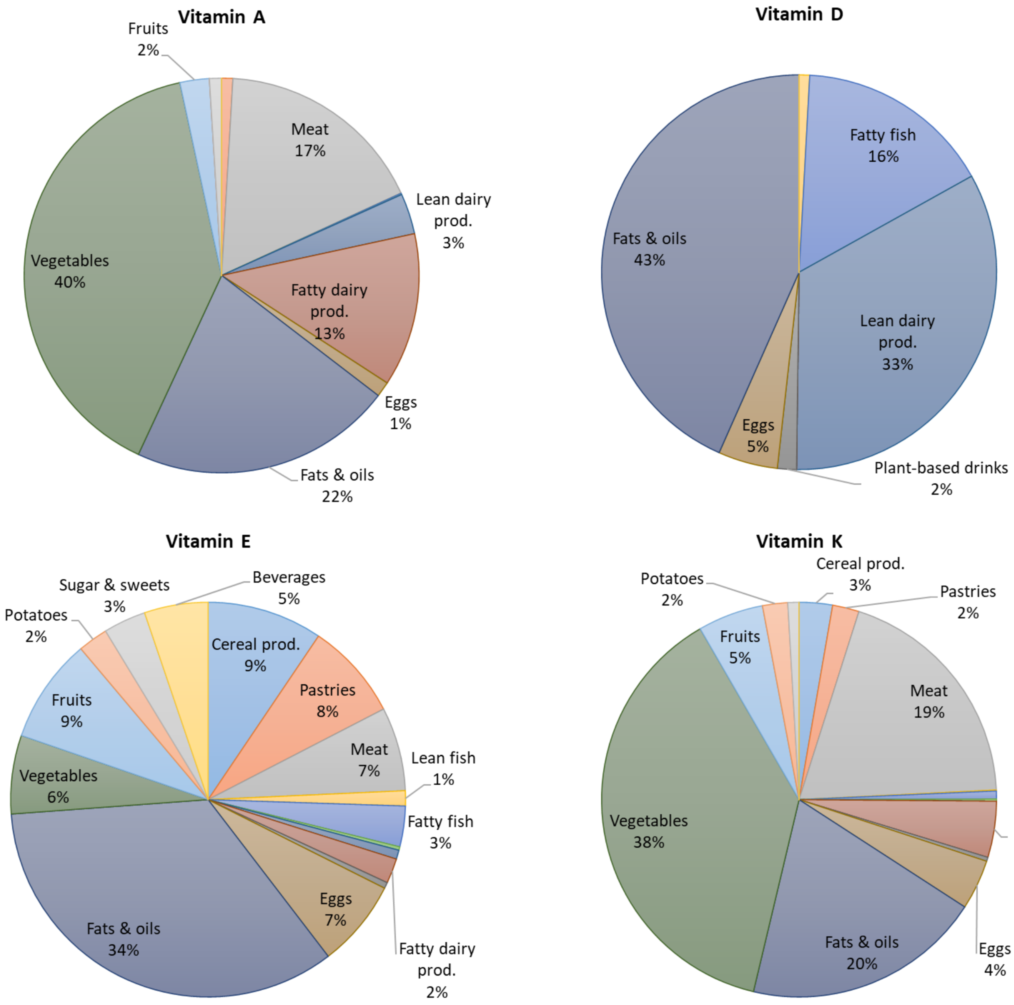

Figure 9. Percentage contribution to the per capita intake of fat-soluble vitamins (A, D, E, K) from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a vitamin below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

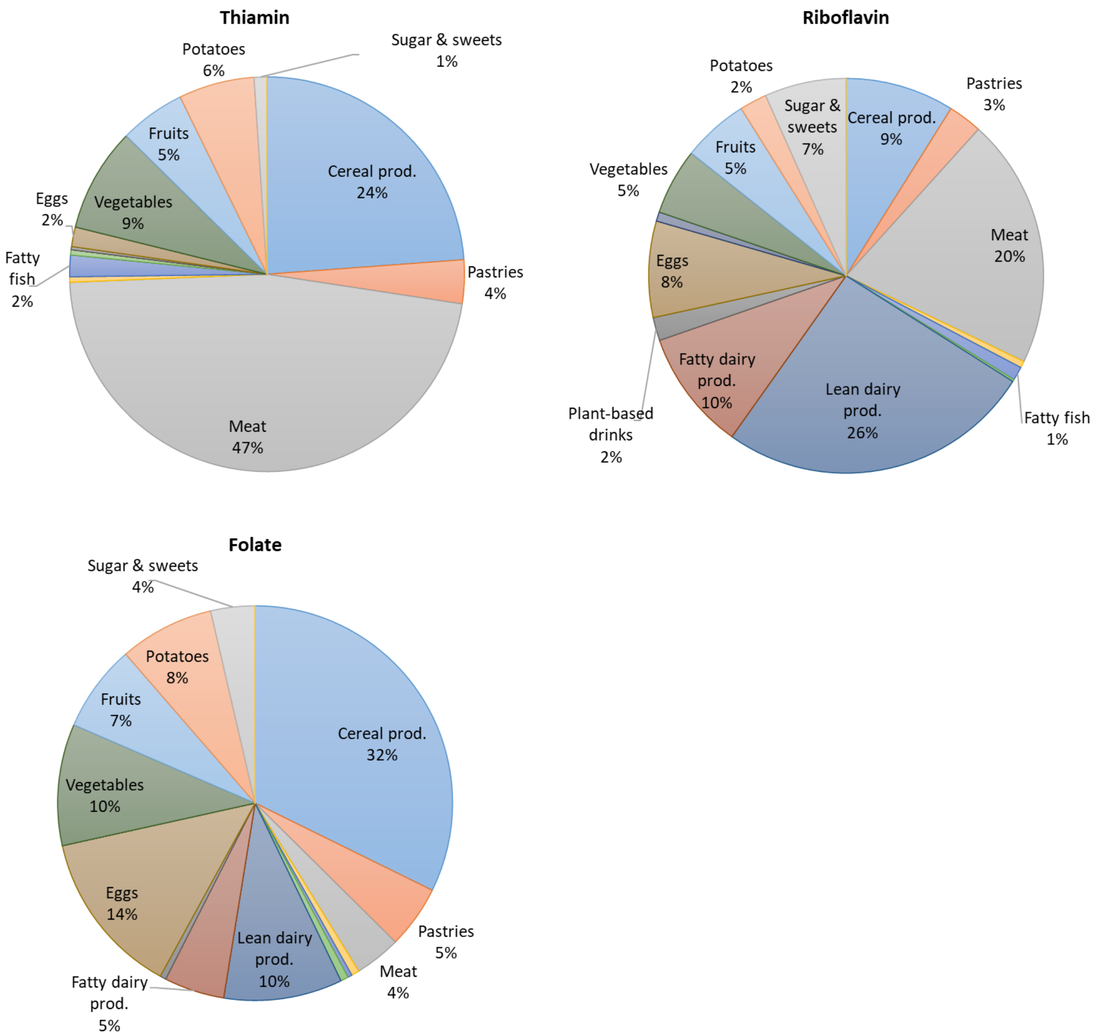

Figure 10. Percentage contribution to the per capita intake of water-soluble vitamins (thiamin, riboflavin, folate) from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a vitamin below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

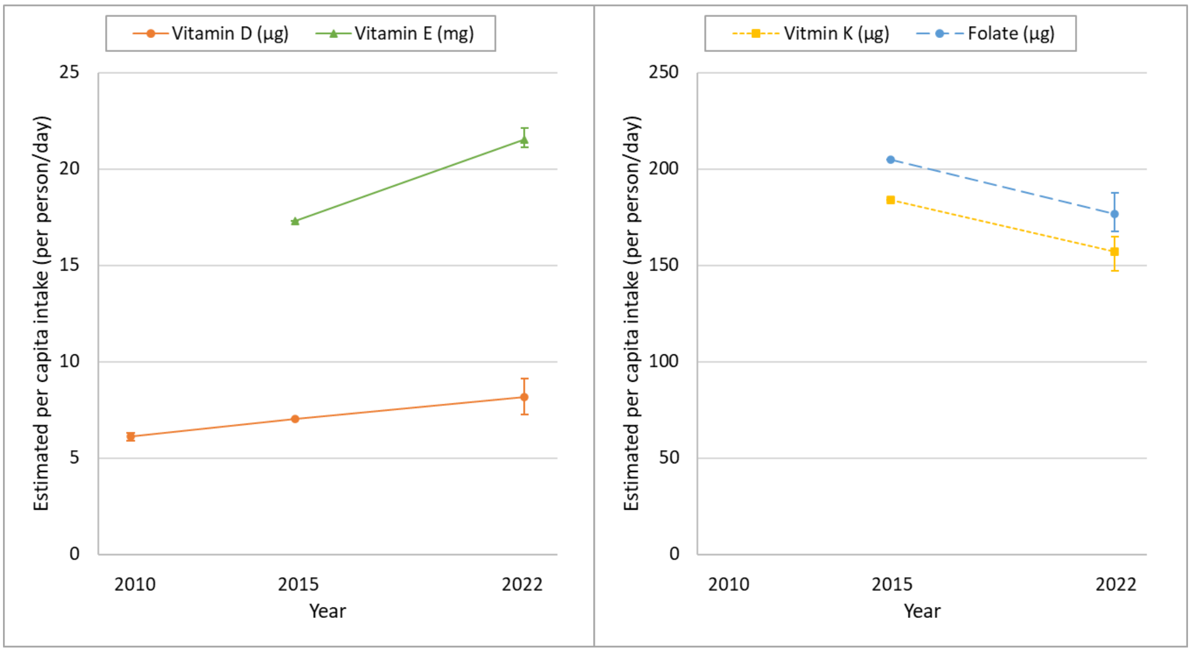

Figure 11. Estimated per capita intake of vitamins in market basket studies over time.

Note, that the per capita intake is a function of per capita consumption and compound concentrations in the food groups. Intake from coffee and tea is not included. Vertical lines indicate minimum and maximum values. Number of samples per food group was: N=2 (2010), N=1 (2015), N=3 (2022). Vitamin E, vitamin K, and folate has previously been determined in 2015 only. Vitamin A, thiamin and riboflavin has not been analysed in market basket studies before 2022 and are not included in the figure.

8.3.3 Risk and benefit assessments

Assessments of benefits or risks with the per capita intakes of vitamins in the Market Basket 2022 was mainly evaluated using AR and upper levels (UL) for adults 25-50 years as defined in the NNR (Blomhoff et al., 2023). Provisional AR was used if no AR was established. Per capita intakes were also compared with RI or adequate intakes (AI) for adults 25-50 years as defined in NNR (Blomhoff et al., 2023).

Figure 12 shows the per capita intakes of vitamins in relation to AR or provisional AR. Value below one indicates insufficient intake at population level. The estimated per capita intakes of most vitamins were above AR, indicating adequate intakes at population level. However, there seemed to be a small margin for vitamin D, and the intake of folate was below AR.

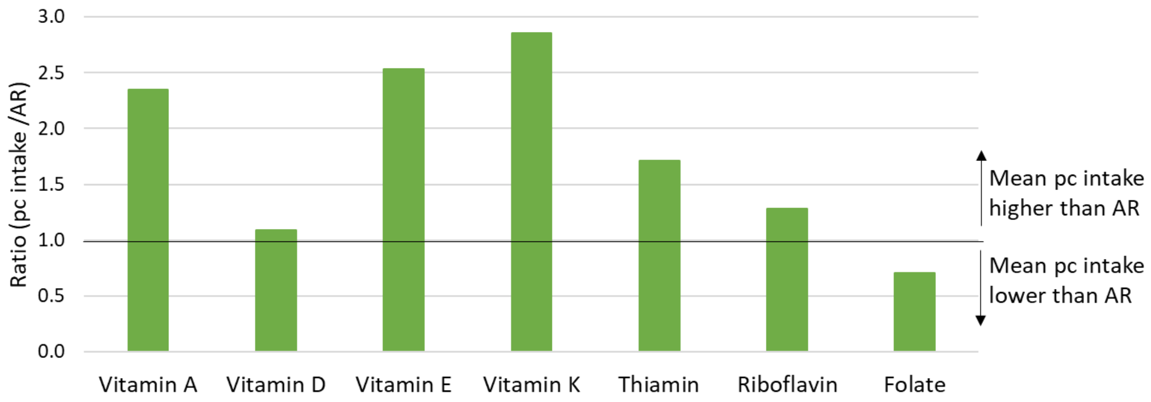

Figure 12. Estimated per capita (pc) intakes of vitamins in the Market Basket 2022 in relation to average requirement (AR) or provisional AR.

Recommendations for adults 25-50 years are used (Blomhoff et al., 2023). Mean AR was used if AR was different for men and women.

Vitamin A

Vitamin A is important for the nighttime vision and in the systemic maintenance of growth and integrity of cells in body tissues (Blomhoff et al., 2023). The per capita intake of 1400 RE/day was far above both AR (540 RE/day for women and 630 RE/day for men) and RI (700 RE/day for women and 800 RE/day for men). AR was also reached in the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). There was a margin to the UL of 3000 RE/day (Blomhoff et al., 2023).

Vitamin D

Vitamin D has an important role in calcium and phosphorus metabolism and in the maintenance of a healthy skeleton. It is also associated with lower total mortality and cancer mortality. The estimated per capita intake (8.2 µg/day, Table 13) was in line with AR (7.5 µg/day) but below RI (10 µg/day) (Blomhoff et al., 2023). In Riksmaten adults 2010-11 (Amcoff et al., 2012), mean intake of vitamin D for men was in line with AR whereas the intake for women was below the recommendation. Intake was also below AR in Swedish adolescents (Warensjö Lemming et al., 2018b). Both these surveys were however conducted before the fortification policy in 2018 (Swedish Food Agency, 2018, Itkonen et al., 2021). Vitamin D is also produced in the skin during sun exposure, complicating the assessment of an adequate vitamin D status in the population. Even though few adults had plasma/serum 25-hydroxyvitamin D concentrations below 30 nmol/L, indicating deficiency (Nälsén et al., 2020), concentrations vary depending on several factors such as season, country of birth, age (Nälsén et al., 2020, Warensjö Lemming et al., 2022). The per capita intake was below UL of 100 µg/day (Blomhoff et al., 2023).

Vitamin E

Vitamin E (α-tocopherol) is an antioxidant and prevents oxidative damage of molecules such as DNA or lipids. Provisional AR is set to 8 and 9 α-TE/day for women and men, respectively. AI is set to 10 and 11 α-TE/day for women and men, respectively (Blomhoff et al., 2023). The estimated per capita intake of vitamin E (22 mg/day, Table 13) was far above both the provisional AR and the AI. This is in line with results from the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). The per capita intake was below the UL of 300 mg/day (Blomhoff et al., 2023).

Vitamin K

Vitamin K is an essential factor for vitamin K dependent proteins involved in functions such as coagulation, bone health and vascular calcification (Blomhoff et al., 2023). The per capita intake of vitamin K (160 µg/day, Table 13) was far above both the provisional AR (50 µg/day for women and 60 µg/day for men) and the AI (65 µg/day for women and 75 µg/day for men) (Blomhoff et al., 2023). There is no set UL for vitamin K (Blomhoff et al., 2023).

Thiamin (vitamin B1)

Thiamin is a coenzyme in the metabolism of carbohydrates and branched-chain amino acids (EFSA, 2016a). The estimated per capita intake of 1.2 mg/day (Table 13) was above the AR (0.65 mg/day for women and 0.75 for men). It was also slightly higher than the RI of 0.9 mg/day for women and 1.1 mg/day for men (Blomhoff et al., 2023). This is in agreement with results from the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). There is no UL for thiamin (Blomhoff et al., 2023).

Riboflavin (vitamin B2)

Riboflavin functions as cofactors of flavoprotein enzymes involved in several redox reactions in the energy metabolism (Blomhoff et al., 2023). The estimated per capita intake (1.7 mg/day, Table 13) was above both the AR (1.3 mg/day) and RI (1.6 mg/day). An adequate intake of riboflavin agrees with the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). There is no UL for riboflavin (Blomhoff et al., 2023).

Folate (vitamin B9)

Folate is an essential cofactor for enzymes involved in the biosynthesis of nucleotides (RNA and DNA). Folate intake prevents against folate-deficient anaemia and reduce the risk of neural tube defects in infants (Blomhoff et al., 2023). The estimated per capita intake (180 µg/day, Table 13) was below the AR of 250 µg/day (Blomhoff et al., 2023). However, assessment of folate intake is, in addition to traditional limitations, also complicated by challenges in quantification of folate concentrations in foods. Analytical methods may differ up to 30% (Öhrvik et al., 2018). Folate is also sensitive to light and oxidation and is partly degraded by cooking (Blomhoff et al., 2023). Therefore, folate intake often is complemented with blood folate as a biomarker for status. Biomonitoring in Riksmaten adults 2010-11 showed that the prevalences of low erythrocyte and plasma folate concentrations were low in Swedish adults, not considering requirement during pregnancy (Öhrvik et al., 2018). The UL is set for synthetic folic acid (7 mg/day) (Blomhoff et al., 2023). Hence, the UL is far above the estimated folate intake.

8.3.4 Conclusion

The estimated population average supplies of vitamin A, D, E (α-tocopherol), K, thiamin (vitamin B1), riboflavin (vitamin B2) and folate (vitamin B9) were determined in the Market Basket 2022. Most of the vitamins were far above their AR with a marginal (Figure 12). This could strengthen the accuracy of the conclusion of an adequate intake at populational level, considering that the market basket studies do not adjust for food waste, and thereby overestimate the per capita intake. Hence, for vitamin A, E, K, thiamin and riboflavin, a sufficient intake in the Swedish population is indicated.

For vitamin D, there was a smaller margin between the per capita intake and AR. This could imply that the intake is adequate in the general Swedish population but that there are groups at risk of deficiency. This is in line with other studies (Warensjö Lemming et al., 2022, Nälsén et al., 2020). The higher vitamin D fortification of fluid dairy products implemented in 2018 (Swedish Food Agency, 2018, Itkonen et al., 2021) have led to a higher per capita intake of vitamin D from this food group despite decreased consumption.

The estimated per capita intake of folate was below the AR, which could indicate a suboptimal intake in the general population. However, there are analytical methodological challenges with quantification of folate content in foods limiting interpretations of an adequate folate intake. Therefore, intake estimations often are complemented with status assessed by plasma or serum folate concentrations. A previous study has shown a low prevalence of folate deficiency in the Swedish adult population, but that it is difficult for fertile women to obtain optimal folate status to reduce risk of neural tube defects via food only, without folic acid supplements (Öhrvik et al., 2018).

8.4 Minerals

Five essential macro elements and nine essential trace elements were analysed in the Market Basket 2022. The macro elements were calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), and phosphorus (P). The essential trace elements were cobalt (Co, essential as a component of vitamin B12), chromium (Cr), cupper (Cu), iron (Fe), iodine (I), manganese (Mn), molybdenum (Mo), selenium (Se), and zinc (Zn)). ALS Scandinavia performed the chemical analyses (except for iodine) using High Resolution Inductively Coupled Plasma Mass Spectrometry (HC-ICP-MS). Iodine concentrations were analysed by SGS Analytics using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The chemical analyses are described in Appendix 4 (section A 4.3). LODs are shown in Table 14. LOQ is calculated by multiplying LOD with 3.3.

Table 14. Limits of detection for analyses of minerals in the Market Basket 2022.

Type of sample	Limits of detection (µg/kg)						
	Ca	Co	Cr	Cu	Fe	I[1]	K
Solid	696	0.24	2.2	4.3	66	10	2567
Liquid	200	0.20	2	5	50	10	100
	Mg	Mn	Mo	Na	P	Se	Zn
Solid	43	2.6	0.01	1620	172	8.3	72
Liquid	50	5	1	200	100	5	20

1 µg/kg = 0.001 mg/kg = 0.1 µg/100 g = 0.0001 mg/100

[1] Limit of quantification (LOQ)

8.4.1 Concentrations in food groups

Concentrations of minerals in the different food groups in the Market Basket 2022 are presented in Table 15. According to the EU regulation for nutrient claims (Regulation (EC) No 1924/2006), significant amount of minerals corresponds to 15% of the nutrient reference values according to EU regulation 1169/2011 (Regulation (EU) No 1169/2011). The purpose of the regulation is to harmonise the provisions for nutrition and health claims for commercial communication of individual products. An evaluation of the nutrient content of the food groups in the Market Basket 2022 was done using the EU regulation 1169/2011 (Regulation (EU) No 1169/2011). It should however only be considered as an indication and individual food items can still have significant amounts of minerals although the food group has a content below the requirement.

Calcium (Ca)

Fatty and lean dairy products, and pizza/hand pie had the highest calcium concentrations (Table 15). The calcium contents of these food groups fulfilled the criterion for significant amount, i.e. corresponded to more than 15% of the nutrient reference value (800 mg/100 g) (Regulation (EU) No 1169/2011).

Cobalt (Co)

The highest cobalt concentrations were found in sugar/sweets, meat substitutes, and pastries (Table 15). EU has not set any nutrient reference value for cobalt.

Chromium (Cr)

Cereal products, pastries, pizza/hand pie, meat, meat substitutes, vegetables, and sugar/sweets had a chromium content corresponding to more than 15% of the nutrient reference value (40 µg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011). The highest chromium concentrations were found in sugar/sweets, pastries, and meat substitutes (Table 15).

Copper (Cu)

Meat substitutes, cereal products, and sugar/sweets had the highest copper concentrations (Table 15). The levels corresponded to more than 15% of the nutrient reference value (1 mg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Iron (Fe)

The highest iron concentrations were found in meat substitutes, eggs, and cereal products (Table 15). Meat substitutes was the only food group fulfilling the criterion for significant amount, i.e. with an iron content corresponding to more than 15% of the nutrient reference value (14 mg/100 g) (Regulation (EU) No 1169/2011). Iron oxide is used in some meat substitute products for the red colouring. However, the chemical analysis method does not differentiate between diverse forms of iron with varying bioavailability. The bioavailability of iron from food is highly variable, and type of iron in food must be considered. Haem iron found in meat, fish, and seafood are more easily absorbed than non-haem iron. The iron absorption from foods is generally around 10-15% but may vary between less than 2% to 50% depending on individual iron status, type of iron consumed and simultaneous intake of other food components (Domellöf and Sjöberg, 2024). The concentration of iron in meat substitutes has only limited impact on the per capita intake because of the low mean intake of meat substitutes in the population.

Iodine (I)

Lean fish, and eggs had the highest concentrations of iodine (Table 15). The content in these food groups corresponded to more than 15% of the nutrient reference value (150 µg/100 g) and fulfilled the criterion for significant amount (Regulation (EU) No 1169/2011).

Potassium (K)

Meat, processed meat, fatty fish, meat substitutes, and potatoes had a potassium content corresponding to the criterion for significant amount, i.e. more than 15% of the nutrient reference value (2000 mg/100 g) (Regulation (EU) No 1169/2011). The highest potassium concentrations were found in potatoes, meat substitutes, and meat (Table 15).

Magnesium (Mg)

Meat substitutes, cereal products, and sugar/sweets had the highest concentrations of magnesium (Table 15). Meat substitutes was the only food group with a magnesium content corresponding to more than 15% of the nutrient reference value (375 mg/100 g), i.e. fulfilling the criterion for significant amount (Regulation (EU) No 1169/2011).

Manganese (Mn)

Cereal products, pastries, pizza/hand pie, meat substitutes, fruits, and sugar/sweets had a manganese content corresponding to the criterion for significant amount, i.e. more than 15% of the nutrient reference value (2 mg/100 g) (Regulation (EU) No 1169/2011). The highest magnesium concentrations were found in cereal products, and meat substitutes (Table 15).

Molybdenum (Mo)

Cereals, pastries, pizza/hand pie, meat substitutes, and plant-based drinks had a molybdenum content corresponding to more than 15% of the nutrient reference value (50 µg/100 g) and the criterion for significant amount (Regulation (EU) No 1169/2011). The highest concentrations of molybdenum were observed in meat substitutes, and cereal products (Table 15).

Sodium (Na)

The highest sodium concentrations were found in processed meat (640 mg/100 g corresponding to 1.6 g salt), followed by fatty fish (400 mg/100 g corresponding to 1.0 g salt) (Table 15). A health claim of low sodium content may be used on a product if the product contains maximum 0.12 g sodium per 100 g (Regulation (EC) No 1924/2006). The following food groups had sodium concentrations below 0.12 g per 100 g; lean dairy products, plant-based drinks, fruits, vegetables, potatoes, sugar/sweets, beverages, and coffee/tea. The 80% reduction of sodium concentrations in sugar/sweets compared with the Market Basket 2015 was due to exclusion of ketchup (2022 included in vegetables), mustard (excluded), and fatty dressings (2022 included in fats/oils), see Table 3. The reduction in pastries by 24% was probably partly due to the lower proportion of pizza and hand pies (Table 3). However, a reduction of sodium was also seen in the subgroup pizza/hand pies compared with the Market Basket 2015 (3.7 g/kg and 4.6 g/kg, respectively) (Swedish Food Agency, 2017). Therefore, there also seems to be a true sodium reduction in these products.

Phosphorus (P)

Many food groups had a phosphorus content corresponding to more than 15% of the nutrient reference value (700 mg/100 g), i.e. criterion for significant amount (Regulation (EU) No 1169/2011): cereals, pastries, pizza/hand pie, meat, processed meat, lean and fatty fish, meat substitutes, lean and fatty dairy products, plant-based drinks, eggs, and sugar/sweets. The highest phosphorus concentration was obtained in fatty dairy products (Table 15).

Selenium (Se)

Meat, processed meat, lean and fatty fish, fatty dairy products, and eggs had a selenium content corresponding to the criterion for significant amount, i.e. more than 15% of the nutrient reference value (55 µg/100 g) (Regulation (EU) No 1169/2011). The highest concentrations were measured in lean fish, eggs, and fatty fish (Table 15).

Zinc (Zn)

Cereals, pizza/hand pie, meat, processed meat, fatty dairy products, and eggs had a zinc content corresponding to the criterion for significant amount, i.e. more than 15% of the nutrient reference value (10 mg/100 g) (Regulation (EU) No 1169/2011). The highest concentrations of zinc were detected in fatty dairy products, and meat (Table 15).

Table 15. Concentrations of minerals in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	*Pizza, hand pie*	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
Ca	Mean	537	646	1459	110	101	220	142	956	1453	6429	1003	601	112	247	206	65	823	32	52
(mg/kg)	Min	393	416	1288	97	74	192	108	850	1331	6163	943	596	101	229	187	50	627	31	51
	Median	508	657	1420	109	89	198	112	987	1512	6480	1027	602	107	252	196	67	810	32	51
	Max	711	866	1669	123	141	270	206	1031	1517	6643	1039	605	128	262	236	79	1032	33	53
Co	Mean	13	19	10	1.9	1.5	3.5	4.5	21	0.52	1.3	4.4	1.3	0.76	6.7	4.9	7.8	56	0.34	2.7
(µg/kg)	Min	10	16	9.1	1.2	1.3	3.4	4.4	21	0.38	1.2	2.0	1.1	0.40	5.1	4.4	5.1	52	<0.20	2.3
	Median	10	20	10	1.7	1.5	3.4	4.5	21	0.49	1.2	5.3	1.3	0.76	5.4	4.9	7.7	53	0.35	2.8
	Max	19	23	10	2.9	1.7	3.5	4.6	21	0.70	1.6	5.9	1.6	1.1	10	5.3	11	63	0.57	2.9
Cr	Mean	81	190	92	85	35	34	18	115	0	7.9	22	0	11	70	27	47	287	10	0
(µg/kg)	Min	64	177	74	23	24	20	8.5	105	<2.2	5.3	19	<2.2	6.2	18	19	32	263	<2.0	<2.0
	Median	83	196	98	29	33	34	14	108	<2.2	8.6	21	<2.2	10	82	23	33	269	<2.0	<2.0
	Max	96	196	105	204	46	48	32	132	<2.2	10	25	<2.2	16	111	39	75	327	28	<2.0
Cu	Mean	2528	1475	1116	646	643	827	545	2610	102	320	601	710	65	581	1090	966	2070	18	23
(µg/kg)	Min	2368	1244	1102	615	606	664	517	2404	50	317	488	691	50	499	970	764	1735	16	22
	Median	2395	1537	1104	615	642	800	546	2555	64	319	621	716	58	563	1041	1056	1919	18	23
	Max	2821	1646	1141	707	681	1016	574	2870	192	323	695	723	86	682	1260	1077	2557	20	26
Fe	Mean	14	11	8.7	11	11	2.6	3.2	26	0.28	0.89	2.5	18	1.1	4.0	3.1	4.4	13	0.13	0.10
(mg/kg)	Min	13	10	8.2	11	10	2.1	3.1	24	0.18	0.87	1.8	17	1.0	3.2	2.8	4.3	12	<0.05	0.10
	Median	14	12	8.6	11	11	2.9	3.3	25	0.28	0.90	2.6	18	1.1	4.0	3.0	4.4	12	0.05	0.10
	Max	14	13	9.4	11	11	2.9	3.4	30	0.37	0.91	3.0	20	1.2	4.8	3.5	4.5	15	0.30	0.10
I	Mean	57	49	48	142	38	697	173	90	147	177	130	447	36	27	41	16	157	34	15
(µg/kg)	Min	54	43	40	82	28	500	130	62	140	160	120	340	32	20	15	10	120	15	12
	Median	56	47	41	95	32	760	170	99	140	170	120	500	35	21	37	13	120	28	13
	Max	61	57	64	250	53	830	220	110	160	200	150	500	40	40	70	26	230	58	21
K	Mean	2694	2183	2596	3708	3345	2542	3542	4240	1910	946	1951	1579	440	2520	2425	4372	2805	127	980
(mg/kg)	Min	2584	1865	2535	3311	2507	2166	3527	4122	1797	926	1252	1530	413	2418	2344	3877	2408	104	914
	Median	2737	2236	2580	3790	2882	2543	3546	4139	1964	951	2151	1595	453	2488	2357	4155	2816	118	956
	Max	2760	2448	2672	4022	4647	2915	3554	4459	1968	961	2450	1611	453	2653	2575	5085	3191	158	1070
Mg	Mean	473	271	249	226	150	257	290	716	134	257	79	146	20	134	226	252	333	13	57
(mg/kg)	Min	456	235	240	212	144	248	262	686	127	248	62	140	19	131	225	224	314	12	57
	Median	464	286	246	232	148	251	301	688	136	259	79	147	19	133	227	260	325	13	57
	Max	499	291	260	235	158	272	307	774	138	264	97	152	22	139	227	271	359	14	57
Mn	Mean	10807	5269	3547	390	671	319	256	10338	40	135	1275	604	98	1614	3209	1332	3614	26	923

		Cereal products	Pastries	*Pizza, hand pie*	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
(µg/kg)	Min	10311	4440	3176	267	222	274	160	9203	35	126	954	577	74	1496	2897	1138	3033	20	752
	Median	10912	5328	3413	391	624	322	263	9724	41	133	1086	592	104	1619	3078	1302	3392	22	867
	Max	11200	6038	4053	511	1166	362	345	12086	43	144	1784	643	117	1728	3652	1555	4417	35	1150
Mo	Mean	356	160	135	38	36	14	7.6	531	47	59	140	32	13	63	63	68	69	2.4	1.2
(µg/kg)	Min	344	151	133	30	36	12	5.8	433	40	57	93	30	12	52	56	52	68	1.8	1.1
	Median	351	159	135	33	37	13	7.2	565	49	59	113	32	13	67	63	75	68	2.6	1.2
	Max	372	171	137	50	37	16	10	595	52	62	214	34	14	69	70	77	71	2.8	1.2
Na	Mean	2334	2817	3710	3263	6423	3204	4029	3287	325	3593	363	1265	3179	903	189	320	565	52	18
(mg/kg)	Min	2108	2770	3592	2672	6015	2669	3623	2985	315	3232	349	1172	3010	861	183	222	306	44	16
	Median	2347	2793	3763	3518	6495	3269	4011	3350	328	3497	363	1264	3166	913	185	306	555	50	18
	Max	2546	2888	3776	3598	6760	3675	4455	3526	331	4049	377	1357	3361	935	200	432	833	62	19
P	Mean	2262	1552	2236	2428	1935	2010	2666	2590	1409	5257	1136	2801	238	408	433	694	1259	80	43
(mg/kg)	Min	2110	1411	1937	2303	1838	1880	2499	2561	1280	5213	813	2744	237	397	414	539	1100	72	43
	Median	2315	1595	2344	2444	1969	2060	2654	2586	1439	5273	1166	2814	237	411	424	765	1222	80	44
	Max	2361	1649	2428	2537	1999	2090	2844	2623	1506	5285	1429	2843	239	416	462	778	1454	88	44
Se	Mean	43	23	43	125	139	269	173	63	18	111	0	243	10	0	5.7	0	16	0	0
(µg/kg)	Min	32	20	37	115	124	258	156	59	12	104	<8.3	218	9.4	<8.3	<8.3	<8.3	15	<5.0	<5.0
	Median	46	22	42	122	142	270	179	59	20	111	<8.3	244	10	<8.3	<8.3	<8.3	16	<5.0	<5.0
	Max	51	26	48	138	151	280	184	70	22	117	<8.3	265	12	<8.3	8.9	<8.3	18	<5.0	<5.0
Zn	Mean	15	8.5	16	22	16	5.6	4.6	13	4.4	27	1.6	15	0.93	2.7	2.4	3.0	5.6	0.01	0.08
(mg/kg)	Min	14	6.8	15	21	15	5.4	4.2	10	3.6	27	1.0	14	0.90	2.5	2.2	2.8	5.3	<0.02	0.07
	Median	15	9.0	16	23	16	5.6	4.6	11	4.6	28	1.5	14	0.92	2.7	2.4	2.9	5.4	<0.02	0.08
	Max	16	10	16	24	17	5.9	5.0	18	4.9	28	2.3	15	1.0	2.8	2.5	3.4	6.0	0.02	0.08

< indicates a value below limit of detection (LOD). When calculating mean, hybrid bound approach was used. This means that medium bound concentration (0.5*LOD) was imputed for non-detects, with exception for when all three samples in one food group had concentrations of an element below LOD. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

8.4.2 Exposure estimations and time trends

Estimated mean intakes of the minerals in the Swedish population (per capita intakes) are shown in Table 16. The proportional contribution of each food group to the per capita intakes are presented in Figure 13, Figure 14, and Figure 15. The food group cereal products was an important contributor to per capita intake for most of the analysed minerals. The food group cereal products was one of the three major sources for all minerals, except for potassium and iodine, for which it was the fourth major source. Other important food groups for intakes of many minerals were dairy products, vegetables, and fruits.

Figure 16 illustrates changes in estimated per capita intake of minerals in market basket studies since 1999. Per capita intakes in 1999, 2005, and 2010 were estimated by pooled samples analysed in year 2017. Concentrations were analysed in one pooled sample per food group and market basket study. It is possible that loss of water content and other factors have affected the analysed concentrations of these samples, which must be kept in mind when interpreting these time trends. The results from the analyses conducted in 2017 were compared with the analytical results from 1999 and 2010 to see the agreement, which was considered when interpreting the results. No statistical testing of time trends was done due to the low number of observations. For most minerals, no clear time trends were observed, and the change from 1999 was mostly less than 25%. The estimated intake of manganese had increased with almost 50% since 1999. Decreasing time trend was seen for estimated per capita intake of sodium. There was also a small decrease of per capita intake of iron since 2005, but not 1999.

Calcium (Ca)

The per capita intake of calcium (1200 mg/day, Table 16) was higher than in Riksmaten adults 2010-11 (880 mg/day (Amcoff et al., 2012)), whereas it was more in line with results from Riksmaten adolescents 2016-17 (1100 mg/day (Warensjö Lemming et al., 2018b)). Fatty dairy (36%), lean dairy (29%), and cereal (10%) products contributed most to the per capita intake of calcium (Figure 13). There were no changes over time in per capita intake of calcium (Figure 16).

Cobalt (Co)

The per capita intake of cobalt was 14 µg/day. The per capita intake was slightly higher in the Market Basket 2022 compared with 2015 (11 µg/day), which may be explained by inclusion of coffee and tea in the study 2022 (Table 16). No time trend was observed when excluding coffee and tea (Figure 16). The main contributors to the per capita intake of cobalt were sugar/sweets (30%), cereal products (20%), and vegetables (12%) (Figure 13). Intake of cobalt was not determined in the Riksmaten surveys.

Chromium (Cr)

The estimated per capita intake in the population was approximately 100 µg/day (Table 16). This was higher than previously estimated by EFSA (57-84 µg/day (Blomhoff et al., 2023)). Intake of chromium was not determined in the Riksmaten surveys. The per capita intake of chromium was more than doubled in the Market Basket 2022 compared with 2015 (41 µg/day (Swedish Food Agency, 2017)). However, the time trend when including data from all previous market basket studies were fluctuating and no consistent trend was seen (Figure 16). Also, data from the market basket studies between 1999 and 2010 are difficult to interpret because the concentrations of pooled samples from analyses conducted in 2017 were higher than concentrations previously assessed (Becker et al., 2011, Swedish Food Agency, 2012). The estimated per capita intakes in the Market Basket 1999 were 74 and 25 µg/day, using 2017-data and 1999-data, respectively. The intakes in the Market Basket 2010 were 75 vs 38 µg/day using 2017-data and 2010-data, respectively. Hence, the difference between studies may be due to chemical analytical issues and should be interpreted with caution. Sugar/sweets (21%), cereal products (18%), vegetables (17%), and meat (16%) contributed the most to the per capita intake (Figure 13).

Copper (Cu)

The estimated per capita intake for copper (1600 µg/day, Table 16) was similar as in 2015 (1400 µg/day (Swedish Food Agency, 2017)) and there were no changes over time (Figure 16). The main contributor to the per capita intake of copper were cereal products (36%), fruits (15%), and sugar/sweets (10%) (Figure 13).

Iron (Fe)

The per capita intake of iron (10 mg/day, Table 16) was similar as in the Market Basket 2015 (11 mg/day (Swedish Food Agency, 2017)), Riksmaten adults 2010-11 (10 mg/day (Amcoff et al., 2012)), and Riksmaten adolescent 2016-17 (8 mg/day (Warensjö Lemming et al., 2018b)). Cereal products (31%), meat (21%), and vegetables (10%) were the main contributors to the per capita intake of iron (Figure 13). There may be a small decreasing trend in per capita intake of iron since 2005 (Figure 16). Possible explanations are the reduced total meat consumption in the population and that pork consumption has decreased with a concomitant increase of poultry (Swedish Board of Agriculture, 2023), causing a small reduction in iron content of the food group meat.

Iodine (I)

The estimated per capita intake of iodine was 170 µg/day (Table 16), which was lower than in Riksmaten adolescents 2016-17 (250 µg/day (Warensjö Lemming et al., 2018b)). In Sweden, table salt is voluntarily iodized (50 µg/gram). Salt is therefore an important iodine source. The discrepancy in intakes was not surprising because household salt is not included in the market basket studies, whereas all household salt is assumed to be iodized in the Riksmaten studies. Hence, the iodine intake is underestimated in the market basket studies and overestimated in the Riksmaten studies, and the true intake is probably in-between. The major sources of iodine intake in the Market Basket 2022 were lean dairy products (22%) and meat (17%) (Figure 13).

Interestingly, the decreasing per capita intake of iodine since 1999 (Market Basket 2015) could not be seen in the present market basket study. Instead, the iodine intake had increased (Figure 16). Higher concentrations were found in several food groups such as pastries, meat, dairy, eggs, and sugar/sweets. There could be several factors that contributed to the higher iodine content in the present market basket study compared with previous. It could be a consequence of increased use of iodized salt in industrial food production. Further, the milk trade organization and industry have decided to increase iodine in fed as a joint effort to increase iodine in milk (Lantbrukarnas Riksförbund, 2023), which could have contributed already. Organic eggs were included in the present market basket study and not in the previous. This could have contributed to higher concentrations in this food group because organic eggs may have slightly higher iodine content than conventional eggs (Gard et al., 2010).

Potassium (K)

Estimated per capita intake of potassium was 4600 mg/day (Table 16). This was much higher than the mean intakes in Riksmaten adults 2010-11 (3100 mg/day (Amcoff et al., 2012)) and Riksmaten adolescents 2016-17 (2800 mg/day (Warensjö Lemming et al., 2018b)). Potassium is a common component in food additives (Martinez-Pineda et al., 2021), and its use is increasing (Picard, 2019). The higher intake in the Market Basket 2022 could partly be a reflection of the more up-to-date concentration data used in the market basket compared to the food composition data used in the Riksmaten studies. No clear time trend of per capita intake was seen. A lower per capita intake was observed in the latter two market basket studies compared with earlier studies (Figure 16), but data are possibly affected by sample quality in the analyses of samples from market baskets 1999, 2005 and 2010 in 2017. Estimated per capita intake for 1999 was much lower based on concentrations measured in 1999 (3300 mg/day). The main contributors to the potassium intake were meat (16%), potatoes (14%), and vegetables (13%) (Figure 14).

Magnesium (Mg)

The per capita intake of magnesium (403 mg/day, Table 16) was well above the intakes determined in Riksmaten adults 2010-11 (330 mg/day (Amcoff et al., 2012)) and Riksmaten adolescents 2016-17 (290 mg/day (Warensjö Lemming et al., 2018b)). Cereal products (27%), fruits (12%), and meat (11%) were the major sources of the magnesium intake (Figure 14). No changes over time were observed for the per capita intake of magnesium (Figure 16).

Manganese (Mn)

The per capita intake of manganese was 4.8 mg/day (Table 16). This was in line with previous market basket studies, even though a small increasing trend may be indicated (Figure 16).

This possible increase seems to be a consequence of increasing concentrations. Cereal products contributed to half of the manganese intake (51%), Figure 14. Intakes of manganese were not assessed in the Riksmaten surveys.

Molybdenum (Mo)

The estimated per capita intake (162 µg/day, Table 16) was in agreement with intakes observed in previous market basket studies (Figure 16). The majority (49%) of the molybdenum intake was from cereal products (Figure 14). Intakes of molybdenum were not determined in the Riksmaten surveys.

Sodium (Na)

Estimated per capita intake of sodium was 2.4 g/day (Table 16), corresponding to 6.0 g salt. This was lower than the sodium intakes observed in Riksmaten adults 2010-11 (3.1 g/day (Amcoff et al., 2012)) and Riksmaten adolescents 2016-17 (3.4 g/day (Warensjö Lemming et al., 2018b)). The difference between market basket studies and dietary surveys are not surprising since salt used in the household is excluded from the market basket studies, whereas common generic recipes are used to estimate intake of household salt in the Riksmaten surveys. Nevertheless, the market basket study reflects the sodium exposure from products available on the market. Meat (27%), cereal products (22%), and fatty dairy products (11%) were the major contributors to the per capita intake of sodium.

Interestingly, a decreasing time trend was observed for the last two market basket studies (Figure 16). This change seems to be due to lower concentrations in cereal products, and meat (the largest contributors to sodium intake). Lower sodium contents in pizza/hand pies and processed meat were also assessed in the Market Basket 2022 compared to the Market Basket 2015; 4.6 g/kg vs 3.7 g/kg (pizza/hand pie) and 8.7 g/kg vs 6.4 g/kg (processed meat). These subgroups have no data from other market basket studies, but 25% of the food group meat is processed meat. Therefore, a reduction of sodium in this subgroup also effects sodium content in the meat group. Similarly, lower sodium content in soft bread (60% of cereal products), probably have an impact on sodium content in the food group cereal products. This is in line with data provided by representatives for the industry showing reduced salt content in bread and processed meat (Swedish Food Agency, 2024).

Phosphorus (P)

The per capita intake of phosphorus was 2400 mg/day (Table 16). This was higher than in the Market Basket 2015 (1800 mg/day (Swedish Food Agency, 2017)), Riksmaten adults 2010-11 (1400 mg/day (Amcoff et al., 2012)), and Riksmaten adolescents 2016-17 (1500 mg/day (Warensjö Lemming et al., 2018b)). The higher intake in the market basket studies compared with the Riksmaten surveys could be because food waste is not considered in the market basket studies. Another explanation may be that data in the market basket studies are more up to date compared with the food composition database used in the dietary surveys, and therefore more accurately reflect the current concentrations of foods. This is especially prone for foods containing additive phosphates (Itkonen and Lamberg-Allardt, 2017). Phosphorus is a frequent food additive (Tuominen et al., 2022), and changes in food production and additive use may cause variation in concentrations over time. The estimated intake was higher compared with previous market basket studies with estimated intakes between 1800 and 2100 mg/day (Figure 16). The higher estimated intake in the Market Basket 2022 did not seem to be attributed to a specific food group, and the higher concentrations were observed over several food groups. It should be pointed out that the chemical analyses of minerals between 1999 and 2010 were analysed later in 2017, and this could also affect the results. The main contributors to phosphorus intake were cereal products (21%), meat (20%), and lean and fatty dairy products (15% each) (Figure 14).

Selenium (Se)

The estimated per capita intake of selenium was between 64 and 72 µg/day (Table 16). This was higher than the intakes in Riksmaten adults 2010-11 (46 µg/day (Amcoff et al., 2012)) and Riksmaten adolescents 2016-17 (43 µg/day (Warensjö Lemming et al., 2018b)). There were no clear changes over time. Also, data analysed in 2017 differed from previously analytical data, limiting interpretation of time trend. The estimated per capita intakes in the Market basket 1999 were 52 µg/day based on concentrations analysed in 1999 and 80 µg/day based on concentrations analysed in 2017. The estimated intakes in the Market Basket 2010 were 52 µg/day based on concentrations from 1999 and 112 µg/day based on concentrations from 2017 (Figure 16). Meat (37%) contributed the most to selenium intake, followed by cereal products (15%), fatty dairy products (12%) and eggs (11%), Figure 15.

Zinc (Zn)

The per capita intake of zinc was 14 mg/day (Table 16). This was slightly higher than the intakes in the Riksmaten studies (11 mg/day) (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). The major contributors to per capita intake of zinc were meat (31%), cereal products (25%), and fatty dairy products (14%), Figure 15. There was no clear time trend, even if the per capita intake was somewhat higher in the Market Basket 2022 compared with previous market basket studies (Figure 16).

Table 16. Mean daily intake of minerals from food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (mg/person/day)							Per capita intake (µg/person/day)						
			Ca	Fe	K	Mg	Na	P	Zn	Co	Cr	Cu	I	Mn	Mo	Se
Cereal products	226		121	3.1	609	107	527	511	3.4	2.9	18	571	13	2442	80	9.7
Pastries	55		36	0.63	120	15	155	85	0.47	1.1	10	81	2.7	290	8.8	1.3
Pizza, hand pie[1]	11		16	0.10	29	2.7	41	25	0.17	0.11	1.0	12	0.53	39	1.5	0.47
Meat	194		21	2.1	719	44	633	471	4.3	0.37	16	125	28	76	7.3	24
Processed meat[1]	48		4.9	0.51	161	7.2	308	93	0.77	0.07	1.7	31	1.8	32	1.8	6.7
Lean fish	15		3.3	0.04	38	3.9	48	30	0.08	0.05	0.51	12	10	4.8	0.21	4.0
Fatty fish	18		2.6	0.06	64	5.2	73	48	0.08	0.08	0.32	10	3.1	4.6	0.14	3.1
Meat substitutes	3		2.9	0.08	13	2.1	9.9	7.8	0.04	0.06	0.34	7.8	0.27	31	1.6	0.19
		LB									0					
Lean dairy prod.	248	HB	360	0.07	474	33	80	349	1.1	0.13	0	25	36	10	12	4.5
		UB									0.56					
Fatty dairy prod.	70		450	0.06	66	18	251	368	1.9	0.09	0.55	22	12	9.4	4.2	7.7
		LB														0
Plant-based drinks	13	HB	13	0.03	25	1.0	4.7	15	0.02	0.06	0.28	7.8	1.7	17	1.8	0
		UB														0.11
		LB									0					
Eggs	29	HB	17	0.53	46	4.2	37	81	0.42	0.04	0	21	13	18	0.93	7.0
		UB									0.06					
Fats and oils	55		6.2	0.06	24	1.1	175	13	0.05	0.04	0.58	3.6	2.0	5.4	0.72	0.57
		LB														0
Vegetables	245	HB	61	1.0	617	33	221	100	0.65	1.6	17	142	6.6	396	15	0
		UB														2.0
		LB														0.64
Fruits	215	HB	44	0.67	521	49	41	93	0.51	1.0	5.8	234	8.7	690	14	1.2
		UB														1.8
		LB														0
Potatoes	142	HB	9.3	0.62	621	36	45	99	0.43	1.1	6.6	137	2.3	189	9.6	0
		UB														1.2
Sugar and sweets	74		61	1.0	208	25	42	93	0.41	4.1	21	153	12	267	5.1	1.2
		LB		0.03					0	0.08	2.5					0

Food group	Per capita consumption (g/person/day)		Per capita intake (mg/person/day)							Per capita intake (µg/person/day)						
			Ca	Fe	K	Mg	Na	P	Zn	Co	Cr	Cu	I	Mn	Mo	Se
Beverages	262	HB	8.4	0.03	33	3.4	14	21	0	0.09	2.6	4.7	8.8	6.8	0.64	0
		UB		0.04					0.01	0.10	2.8					1.3
		LB									0					0
Coffee and tea	407	HB	21	0.04	399	23	7.1	18	0.03	1.1	0	9.5	6.2	376	0.47	0
		UB									0.81					2.0
		LB									**101**					**64**
Total		**HB**	**1239**	**10**	**4597**	**403**	**2364**	**2404**	**14**	**14**	**101**	**1569**	**167**	**4832**	**162**	**65**
		UB									**103**					**72**
Average requirement[2]			750	9/7	2800	240/280	1500	420	8/11	-	-	700	120	2400	52	60/70
Riksmaten adults[3]			875	10	3119	331	3118	1374	11	-	-	-	-	-	-	46
Riksmaten adolescents[4]			1079	8	2786	293	3352	1510	11	-	-	-	246	-	-	43

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of detection (LOD) is used for non-detects, except for when all three samples in one food group have concentrations below LOD. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOD is used for non-detects).

[1] Pizza/hand pie and processed meat are subgroups of pastries and meat, respectively, and their intakes are included in pastries and meat. The subgroups were therefore not included when calculation of total per capita intake.

[2] Average requirement according to the Nordic Nutrition Recommendations 2023 for females/males 25-70 years (Blomhoff et al., 2023).

[3] Riksmaten adults 2010-11 (Amcoff et al., 2012).

[4] Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b).

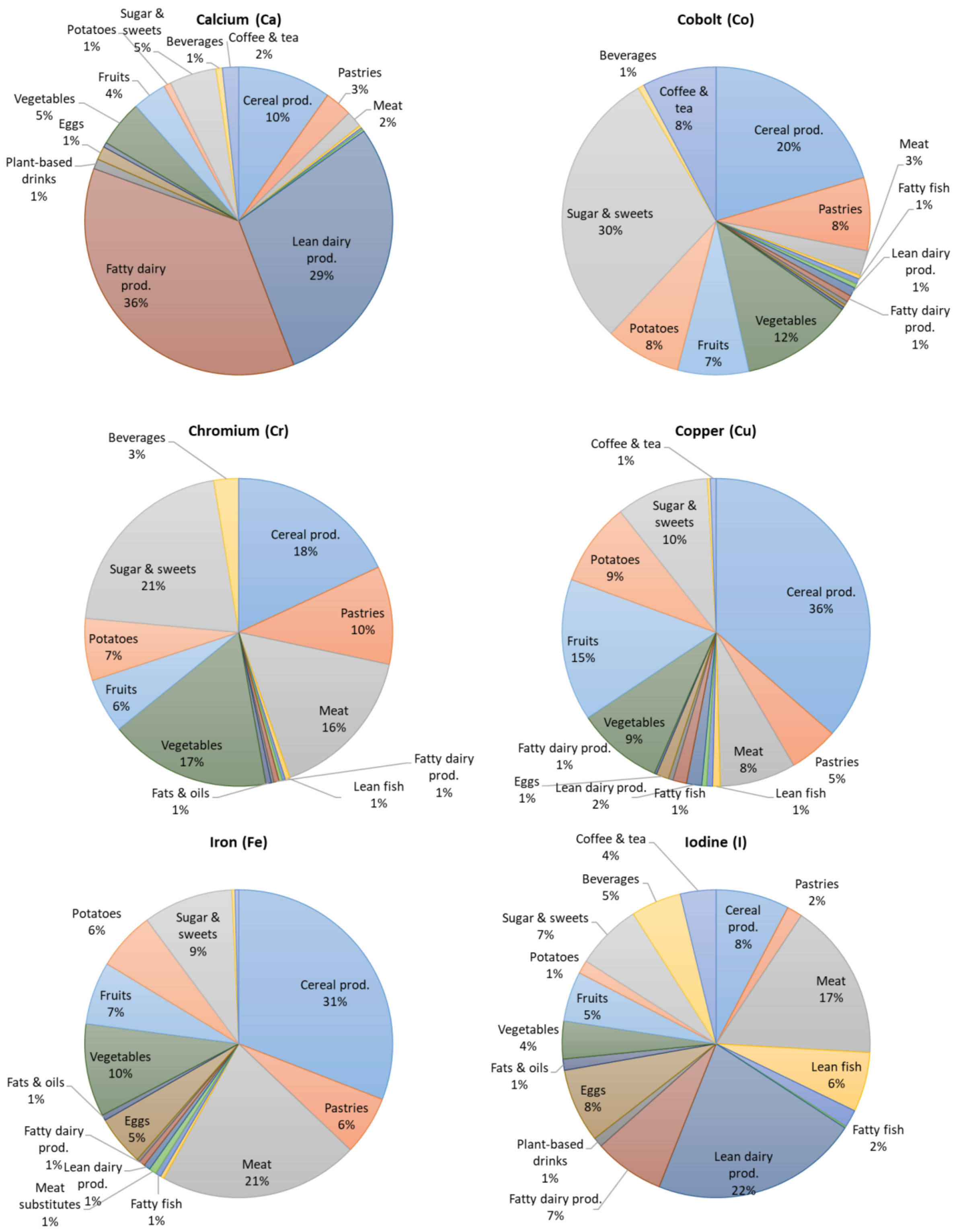

Figure 13. Percentage contribution to the per capita intake of essential minerals (Ca, Co, Cr, Cu, Fe, and I) from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of detection, LOD] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a mineral below LOD. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

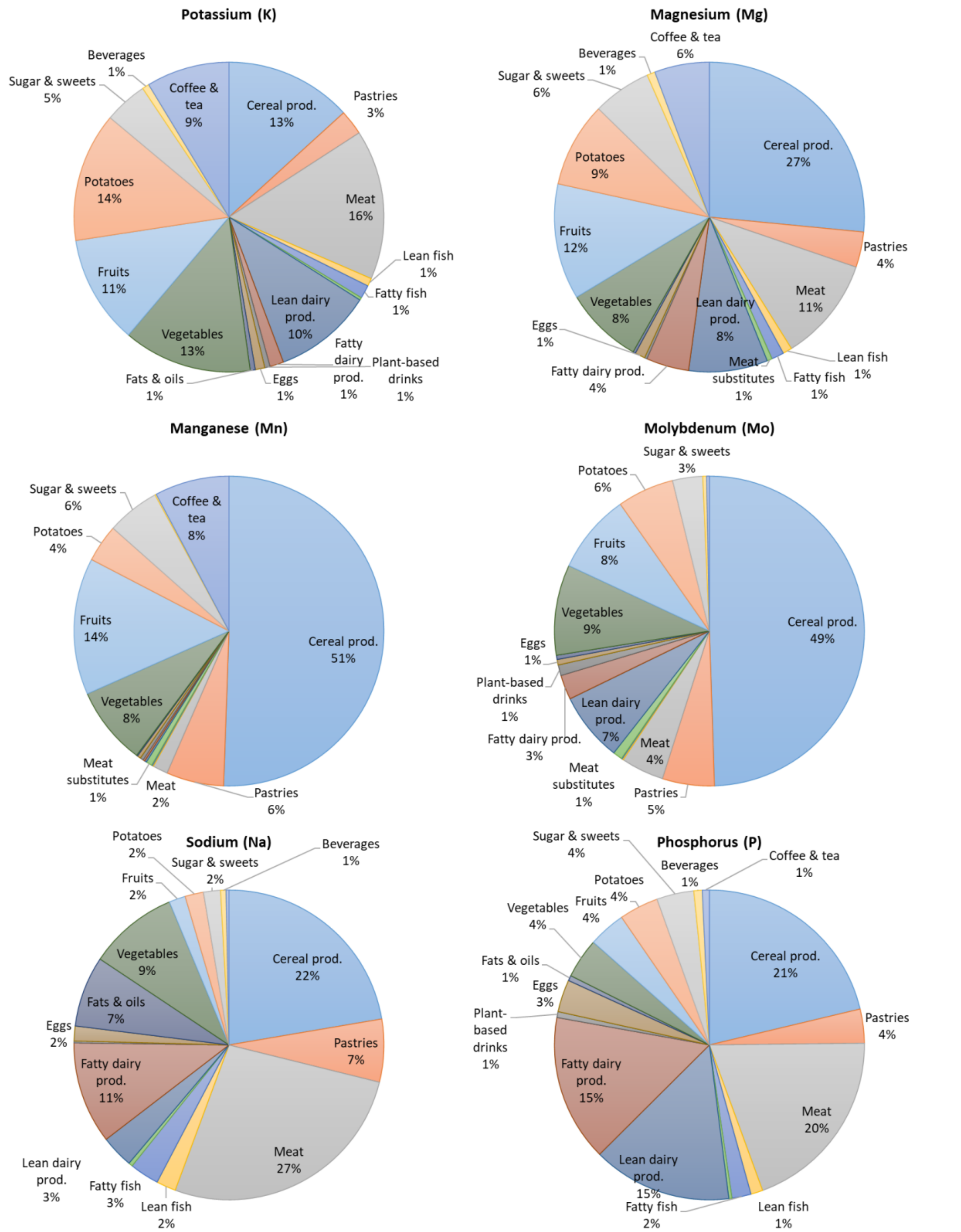

Figure 14. Percentage contribution to the per capita intake of essential minerals (K, Mg, Mn, Mo, Na, and P) from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of detection, LOD] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a mineral below LOD. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

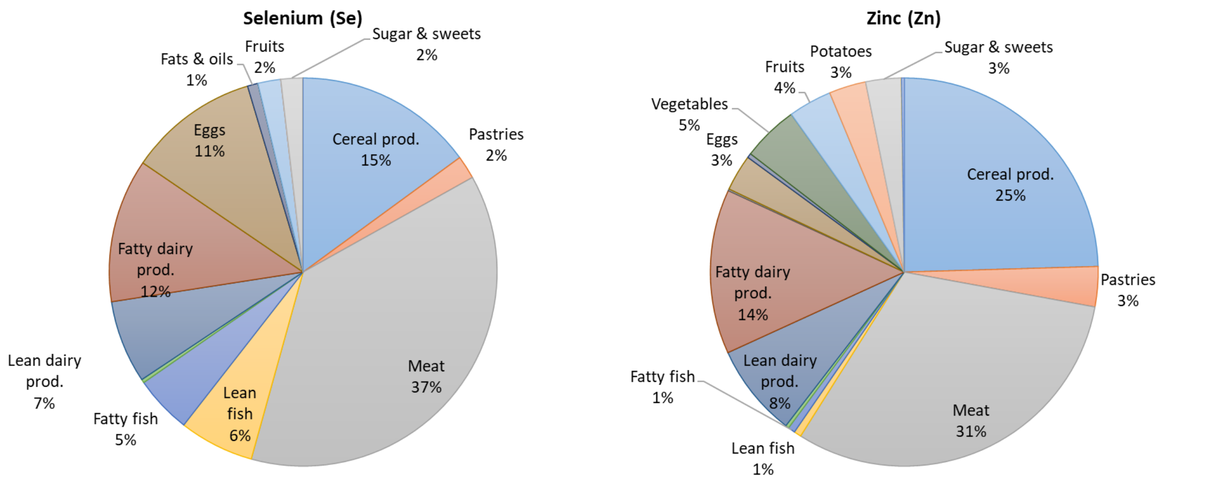

Figure 15. Percentage contribution to the per capita intake of essential minerals (Se, and Zn) from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of detection, LOD] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a mineral below LOD. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

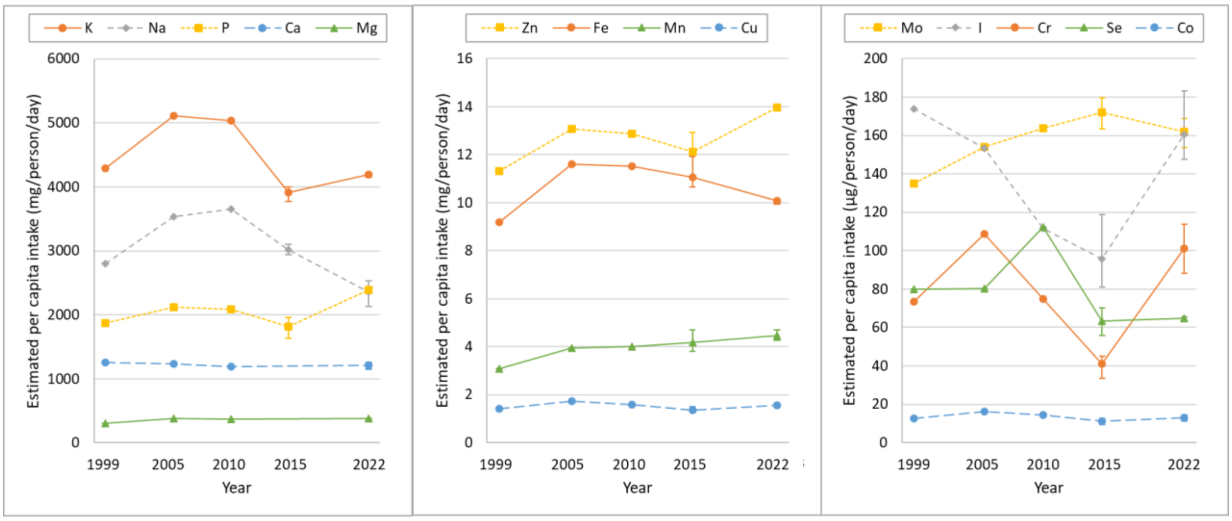

Figure 16. Estimated per capita intake of essential minerals in market basket studies over time.

Note, that the per capita intake is a function of per capita consumption and compound concentrations in the food groups. Intake from coffee and tea is not included. Vertical lines indicate minimum and maximum values in the Market Basket 2015 and 2022. Number of samples per food group was: N=1 (1999), N=1 (2005), N=1 (2010), N=5 (2015), N=3 (2022).

8.4.3 Risk and benefit assessments

Assessments of benefits or risks with the per capita intakes in the Market Basket 2022 was mainly evaluated using AR and UL for adults 25-50 years as defined in the NNR (Blomhoff et al., 2023). Provisional AR was used if no AR was established. Per capita intakes were also compared with RI or adequate intakes (AI) for adults 25-50 years as defined in NNR (Blomhoff et al., 2023).

Figure 17 shows the per capita intake related to AR or provisional AR. Value below one indicates insufficient intake at population level. For all analysed minerals, the estimated per capita intakes were above AR, indicating adequate intakes at population level. However, there seemed to be a small margin for iron and selenium.

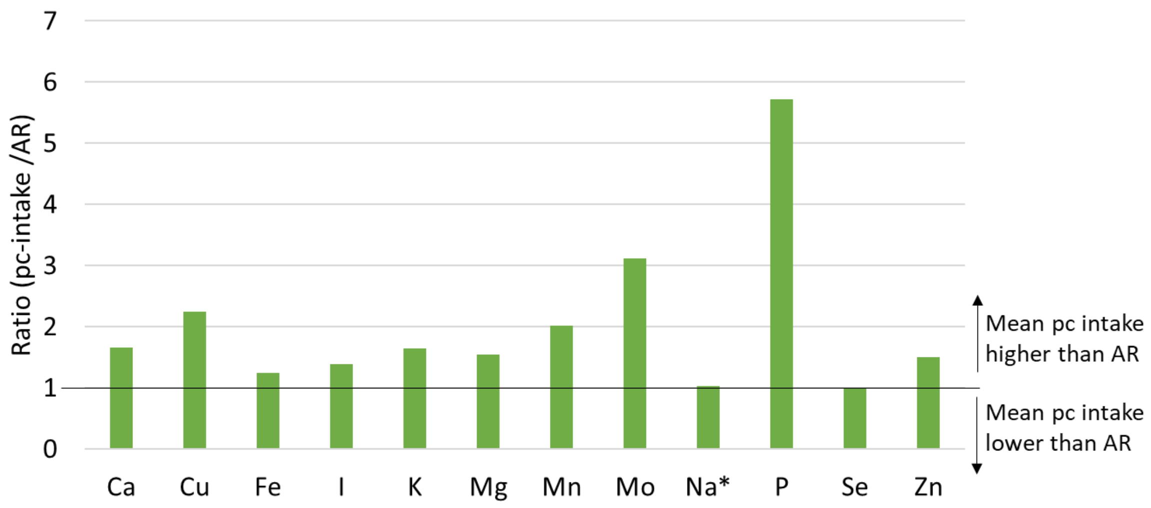

Figure 17. Estimated per capita (pc) intake of minerals in the Market Basket 2022 in relation to average requirement (AR) or provisional AR.

Recommendations for adults 25-50 years are used (Blomhoff et al., 2023). Mean AR was used if AR was different for men and women. Please note that household salt was not included in the study, especially underestimating the intakes of iodine and sodium.

*For sodium, the comparison was not made with AR but with the chronic disease risk reduction intake, i.e. the intake level for when a reduction of chronic disease risk is expected in the general population.

Calcium (Ca)

Calcium is important for skeleton and teeth, but also muscle contraction, nervous system, and blood clotting. AR is based on maintaining a healthy skeleton (Blomhoff et al., 2023). Per capita intake of calcium (1200 mg/day, Table 16) was above the AR (750 mg/day) and RI (950 mg), and below UL (2500 mg/day) (Blomhoff et al., 2023). AR was also reached in Riksmaten adults 2010-11 (Amcoff et al., 2012) and Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b).

Cobalt (Co)

Cobalt is a component for vitamin B12 (cobalamin), which is involved in cell metabolism and the production of red blood cells. There are no established recommended intake or average requirement for cobalt by EFSA or NNR (Blomhoff et al., 2023).

Chromium (Cr)

The biological functions of chromium are not yet determined but it is considered to be involved in insulin sensitivity and cholesterol metabolism (Blomhoff et al., 2023). At present, there are no convincing evidence that chromium is an essential nutrient and therefore no intake recommendations or UL are set by EFSA (EFSA, 2014b) or NNR (Blomhoff et al., 2023). The per capita intake of 101 µg/day (Table 16) was above the adequate intakes set by US Institute of Medicine (25 µg/day for females and 35 µg/day for males) (Institute of Medicine (US) Panel on Micronutrients, 2001).

Copper (Cu)

Copper is a structural component in many proteins. The estimated per capita intake for copper (1600 µg/day, Table 16) was far above AR of 700 µg/day and RI of 900 µg/day (Blomhoff et al., 2023). The intake corresponds to 0.02 mg/kg bw/day. This is below the UL for adults based on copper retention as an early marker of potential adverse effects of 5 mg (corresponding to 0.7 mg/kg bw/day) (Blomhoff et al., 2023).

Iron (Fe)

Iron is essential for transportation of oxygen and functions of many enzymes. The estimated per capita intake of iron in the Market Basket 2022 (10 mg/day, Table 16) was in accordance with AR (9 and 7 mg/day for females and males, respectively) (Blomhoff et al., 2023). AR was also reached in Riksmaten adults 2010-11 (Amcoff et al., 2012). However, the estimated intake in the Market Basket 2022 is average in the population and there are groups (e.g. infants, young children, menstruating or pregnant women, and vegetarians) at risk of iron deficiency in the Nordic countries (Blomhoff et al., 2023). Further, a per capita intake of 10 mg/day meets the AR of all population groups, except for pregnant women (Blomhoff et al., 2023). Because of the narrow margin to AR and that the market basket studies tend to overestimate the intake due to not considering food waste, there is a risk that AR is not reached in all groups. A decreasing trend of iron intake since 2005 was indicated. If this trend continues, this could increase the number of individuals with inadequate iron status. RI for males (9 mg/day) but not females (15 mg/day) were reached (Blomhoff et al., 2023), further empathizing women to be at the highest risk for deficiency.

AR for pregnant women is 20 mg/day and was far above the estimated per capita intake. It was also higher than the intakes in fertile females in Riksmaten adults 2010-11 (around 9-10 mg/day, (Amcoff et al., 2012)), and in Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b). In the latter, around 30% of the teenage girls had plasma ferritin concentrations indicating risk for iron deficiency anaemia (Warensjö Lemming et al., 2018b). Because pregnant women are at risk for iron deficiency anaemia, their status is monitored during pregnancy.

There was a margin to UL set to 60 mg/day in the NNR (Blomhoff et al., 2023) and to the safe level of intake of 40 mg/day suggested by EFSA (EFSA et al., 2024b).

Iodine (I)

Iodine is an essential component of the thyroid hormones and thereby important for metabolic regulation and growth. The estimated per capita intake of iodine is probably underestimated at population level because of the exclusion of iodized household salt. Despite this, the intake (170 µg/day, Table 16) was above the provisional AR (120 µg/day) and AI (150 µg/day) (Blomhoff et al., 2023). The decreasing time trend of estimated iodine intake observed in previous market basket studies was not continued and the intake had increase in the Market Basket 2022. Adequate iodine intake was also reported in Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b). The UL of iodine is 600 µg/day (Blomhoff et al., 2023).

Potassium (K)

Potassium is essential for normal cell functions and fluid balance. The intake recommendation is based on associations between potassium intake and normal blood pressure (Blomhoff et al., 2023). Estimated per capita intake of potassium was 4600 mg/day (Table 16), which was far above the provisional AR of 2800 mg/day and AI of 3500 mg/day (Blomhoff et al., 2023). Intakes above AR was also seen in Riksmaten adults 2010-11 (Amcoff et al., 2012) and Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b). There is no UL for potassium in NNR (Blomhoff et al., 2023).

Magnesium (Mg)

Magnesium is a cofactor of many enzymes and essential for several physiological processes. The provisional AR for magnesium (240 and 280 mg/day for females and males, respectively (Blomhoff et al., 2023)) was far reached by the estimated per capita intake of 400 mg/day (Table 16). The intake was also above RI (300 and 350 mg/day for females and males, respectively) (Blomhoff et al., 2023). Intakes above AR was also seen in Riksmaten adults 2010-11 (Amcoff et al., 2012) and Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b). There is no UL for magnesium from diets. UL in dietary supplements is set to 250 mg/day (Blomhoff et al., 2023).

Manganese (Mn)

Manganese is essential and involved in synthesis and activation of enzymes. The estimated mean intake in the Market Basket 2022 (4.8 mg/day, Table 16) was far above the provisional AR (2.4 mg/day) and AI (3 mg/day) (Blomhoff et al., 2023). There is no UL set for manganese (Blomhoff et al., 2023).

Molybdenum (Mo)

Molybdenum serves as a cofactor in some enzymes. The estimated per capita intake (162 µg/day, Table 16) was more than twice as high as the provisional AR (52 µg/day) and AI (65 µg/day) (Blomhoff et al., 2023). There was a margin to the UL, which is set to 600 µg/day (Blomhoff et al., 2023).

Sodium (Na)

Sodium is important for the intra- and extracellular osmolality. An intake of 1.5 g/day is estimated sufficient for maintained sodium balance and set as the lower intake level (Blomhoff et al., 2023). High sodium intakes are associated with high blood pressure and mortality (Blomhoff et al., 2023). The estimated per capita intake of sodium was 2.4 g/day (Table 16), which is equivalent to 6.0 g salt (NaCl). Despite that salt intake is underestimated in the market basket studies due to the exclusion of household salt, the estimated mean intake was 1.6 times higher than the recommended adequate intake of 1.5 g/day (corresponding to 3.75 g/day of salt) (Blomhoff et al., 2023). A sodium intake of 2.4 g/day is also higher than the chronic disease risk reduction of 2.3 g/day (5.75 g salt). Lowering the intake below this level is expected to reduce chronic disease risk within the general population (Blomhoff et al., 2023). This shows that the population target of 2.3 g/day of sodium is exceeded, even if no salt is used in the household at all. If adding sodium estimated by salt consumption in the statistics from the SBA (2.7 g salt/day or 1.1 g sodium/day (Swedish Board of Agriculture, 2021b)), total per capita intake of sodium was estimated to 3.4 g/day, corresponding to 8.6 g salt/day. Too high intakes of sodium and salt was also reported in the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). A decreasing trend of sodium seen in the Market Basket 2022, indicates lower sodium exposure from products such as pizza/hand pies, and processed meat. This is beneficial considering that these groups each contributes to more than 5% of the sodium intake (Swedish Food Agency and Löfvenborg, 2023).

Phosphorus (P)

Phosphorus is important for the bone mineralization, cell structure and cellular metabolism. The estimated per capita intake in the population (2400 mg/day, Table 16) was almost six times higher than the provisional AR (420 mg/day (Blomhoff et al., 2023)). High intakes of phosphorus have adverse effects on kidney, bone and cardiovascular health and UL is set to 3000 mg/day (Blomhoff et al., 2023). Hence, there was a small margin between estimated per capita intake and UL. High intakes have also been seen in the Riksmaten surveys with medians between 1300 and 1800 mg/day and 95th percentiles between 2100 and 2900 mg/day (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). If there is an increasing time trend, this may be troublesome for individuals with kidney disease considering that there is no product labelling for phosphorus. Higher intake of phosphorus is associated with increased mortality in patients with severe chronic kidney disease (Hou et al., 2017, Da et al., 2015), but not with milder disease (Murtaugh et al., 2012). We did not consider whether the phosphorus was natural (organic) or added (inorganic), which could be relevant due to their different bioavailabilities. Added inorganic phosphorus have higher bioavailability (80-100%) than natural phosphorus (less than 60%). Of the organic sources, animal-derived phosphorus are more easily absorbed than plant-derived (Calvo et al., 2014).

Selenium (Se)

Selenium is an essential component of antioxidant enzymes and important for normal function of the thyroid hormones. The estimated average intake in the population (64-72 µg/day, Table 16) was equivalent the provisional AR (60 µg/day for females and 70 µg/day for males (Blomhoff et al., 2023)). Hence, the intake at a population level seems to be sufficient. However, it should be kept in mind that food waste is not included in the Market Basket 2022, which overestimates the intake. Therefore, there may be a narrow margin to AR. A low selenium intake in the population was also obtained in the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b), were all population groups were below AR based on the NNR (Blomhoff et al., 2023).

High intakes of selenium may cause adverse effects on liver, peripheral nerves, skin, nails, and hair, but the estimated intake was far below UL (255 µg/day) (Blomhoff et al., 2023).

Zinc (Zn)

Zinc is an essential element with structural and catalytic roles in all seven classes of enzymes. The AR of 8.1 mg/day for females and 10.6 mg/day for males (Blomhoff et al., 2023) were reached by the estimated average intake in the population (14 mg/day, Table 16). Dietary phytate inhibit zinc absorption. Therefore, plant-based diets can increase the need of zinc from diets. AR at a higher phytate intake of 1200 mg/day (instead of 600 mg/day) are set to 10 mg/day for females and 13 mg/day for males. Hence, the per capita intake of zinc is slightly above AR even at higher phytate intakes (EFSA, 2014c). Adequate intakes were also obtained in the Riksmaten surveys (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). There was a margin to UL of zinc set to 25 mg/day (Blomhoff et al., 2023).

8.4.4 Conclusion

The estimated population average supplies of the fourteen essential minerals analysed in the Market Basket 2022, and for which there was an AR, were above AR (i.e. calcium, chromium, copper, iron, potassium, magnesium, manganese, molybdenum, phosphorus, selenium, and zinc). No assessment was made for cobalt as no dietary reference values were available. Most of the minerals were above AR with a marginal. This could strengthen the accuracy of the conclusion of an adequate intake at populational level, considering that the market basket studies do not adjust for food waste, and thereby overestimate the per capita intake. However, the estimated supplies of selenium and iron indicate risk for deficiency of these minerals in the population. In contrast, the estimated population mean intake of sodium from foods was too high. The high supply of phosphorus indicates a narrow span to levels where it could have health implications.

The estimated average intake of selenium was in line with AR. However, because the estimations in the market basket studies tend to overestimate the actual intake, the narrow margin indicates that there is a risk of selenium deficiency in the population. The recommended intake of selenium was increased in the updated NNR (Blomhoff et al., 2023), with the result that both adults and adolescents in the Riksmaten surveys also are below AR (Amcoff et al., 2012, Warensjö Lemming et al., 2018b). Taken together, the mean selenium intake in the Swedish population indicates a risk of insufficient intake at populational level.

The estimated intake of iron was in accordance with AR but the margin for especially females was small. This indicates that fertile women could be at risk for iron deficiency anaemia, which is in line with results from Riksmaten adolescents 2016-17 (Warensjö Lemming et al., 2018b).

Even though the estimated intake of sodium in the Market Basket 2022 is underestimated, due to the exclusion of household salt, the intake was at a level where it is expected to increase the risk of chronic disease in the general population. However, a decreasing time trend of sodium intake was seen and if it continues, this is expected to have beneficial public health effects.

For phosphorus, there was a small margin between estimated supply and UL. A high intake of phosphorus has adverse effects on kidneys, but also bone and cardiovascular health. A high intake could be problematic for especially people with chronic kidney disease because of limited capacity to remove phosphorus from the body.

8.5 Metals

There are several metals found in food. Some are toxic to humans and are present in the food mainly due to their natural presence. Arsenic though semi metallic is sometimes included in the category of metals as well. Some, like cadmium and lead, occur at elevated levels due to human activity and others like silver and aluminium occur naturally but may also be added as food additives. Seven metals were analysed to give their total content in the different food categories: aluminium (Al), silver (Ag), cadmium (Cd), mercury (Hg), lead (Pb), arsenic (As) and nickel (Ni). For arsenic, additional analyses were performed to obtain the content of inorganic arsenic (iAs), which is considered the most toxic form of arsenic that is present in food.

ALS Scandinavia performed the chemical analyses using HC-ICP-MS. The analysis of inorganic arsenic was performed by HPLC-ICP-MS at the Swedish Food Agency. The chemical analyses are described in more detail in Appendix 4 (section A 4.4). Limits of detection are shown in Table 17.

Table 17. Limits of detection for analyses of metals in the Market Basket 2022.

Type of sample	Limits of detection (µg/kg)							
	Al	Ag	As	iAs[1]	Cd	Hg	Ni	Pb
Solid	90	0.24	0.44	1	0.02	0.35	2	0.30
Liquid	50	0.05	0.5	0.4[2]	0.05	0.2	2	0.5

[1] In the analysis of iAs in fish it was hard to separate two similar peaks which lead to a high LOQ of 10 µg/kg.

[2] Liquid analyses only apply to coffee and tea.

8.5.1 Concentrations in food groups

Levels of metals in the different food groups in the Market Basket 2022 are presented in Table 18.

Arsenic (As)

The analysis of arsenic was divided into the total amount of arsenic, tAs, and inorganic arsenic, iAs. Fish contained the highest levels of tAs (mainly organic forms), when comparing all food categories. The mean levels in fatty fish were 1100 µg tAs/kg and the mean for lean fish was 4980 µg tAs/kg.

For inorganic arsenic the highest level was found in cereals with a mean concentration of 9.4 µg/kg followed by meat substitutes with a mean concentration of 3.3 µg/kg. In the analysis of iAs in fish it was hard to separate two similar peaks which caused a high LOQ.

Aluminium (Al)

Meat substitutes contained the highest levels of aluminium with a mean level of 6706 µg/kg followed by pizza and hand pie with a mean exposure of 5300 µg/kg.

Silver (Ag)

Lean fish products contained the highest levels of silver with a mean level of 11 µg/kg followed by potatoes with a mean level of 0.96 µg/kg.

Cadmium (Cd)

Cereal products contained the highest levels of cadmium with a mean level of 30 µg/kg followed by potatoes with a mean level of 26 µg/kg.

Mercury (Hg)

Fish was the category with the highest level of mercury, with a concentration of 30 µg/kg in lean fish and 20 µg/kg in fatty fish.

Nickel (Ni)

The highest concentration of nickel was in sugar and sweets (559 µg/kg). Noteworthy is that plant-based drinks had second highest concentration of nickel (352 µg/kg), especially considering that can more easily be consumed in large amounts. These have not been analysed in the market basket before.

Lead (Pb)

Meat substitutes had the highest concentration of lead with a mean concentration of 3.6 µg/kg followed by pastries with a mean concentration of 2.6 µg/kg. Vegetables were the main contributor to exposure, accounting for around 24% of the total exposure. Cereals also contributed about 18% to exposure.

Table 18. Concentrations of metals in food groups in the Market Basket 2022 (N=3 per food group). All concentrations are given in µg/kg. Inorganic arsenic was not measured in all food groups, which is indicated by NA.

		Cereal products	Pastries	*Pizza, hand pie*	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
Ag	Mean	0.87	0.31	0.38	<0.24	<0.24	11	0.3	0.29	<0.050	<0.24	<0.050	<0.24	<0.24	0.26	0.17	0.96	<0.24	<0.050	<0.050
(µg/kg)	Min	0.74	0.25	0.28	<0.24	<0.24	8.0	0.12	0.12	<0.050	<0.24	<0.050	<0.24	<0.24	0.19	0.12	0.49	<0.24	<0.050	<0.050
	Median	0.83	0.32	0.43	<0.24	<0.24	11	0.27	0.12	<0.050	<0.24	<0.050	<0.24	<0.24	0.27	0.12	1.1	<0.24	<0.050	<0.050
	Max	1.1	0.34	0.45	<0.24	<0.24	13	0.51	0.65	<0.050	<0.24	<0.050	<0.24	<0.24	0.31	0.28	1.3	<0.24	<0.050	<0.050
Al	Mean	4205	3111	5300	443	930	493	275	6706	96	242	959	<90	313	1863	1419	628	4431	66	798
(µg/kg)	Min	1316	2128	4834	301	515	478	248	5844	45	174	829	<90	211	1015	1074	555	4237	25	751
	Median	1371	3100	4918	454	935	479	250	6170	45	180	10244	<90	337	1533	1440	635	4397	63	787
	Max	2007	4103	6147	575	1339	521	326	8103	200	371	1025	<90	392	3039	1744	694	4659	111	856
As	Mean	14	3.9	3.8	2.8	2.7	4980	1100	6.5	1.3	9.3	3.1	7.0	4.2	2.2	4.7	2.4	5.1	0.78	0.33
(µg/kg)	Min	9.6	2.5	3.4	2.2	2.1	3069	934	5.1	0.69	2.0	2.7	6.0	3.6	1.8	2.6	1.7	4.3	0.62	0.25
	Median	11	3.6	3.3	2.5	2.3	4135	1037	6.1	1.2	7.8	2.9	7.3	4.2	1.9	4.5	1.9	5.1	0.74	0.25
	Max	20	5.6	4.3	3.9	3.9	7737	1330	8.4	2.1	18	3.6	7.8	4.9	3.0	7.0	3.6	6.1	0.98	0.51
iAs	Mean	9.4	NA	NA	NA	NA	<10	<10	3.3	NA	NA	1.7	NA	NA	1.3	2.9	NA	2.5	NA	<0.4
(µg/kg)	Min	8.1					<10	<10	2.7			1.5			1.1	1.8		1.6		<0.4
	Median	9.5					<10	<10	3.4			1.5			1.3	2.1		2.1		<0.4
	Max	10.5					<10	<10	3.8			2.0			1.7	4.7		3.6		<0.4
Cd	Mean	29	16	13	1.3	0.82	11	2.1	11	0.053	0.11	1.9	0.047	0.45	12	1.6	26	7.2	<0.05	0.072
(µg/kg)	Min	25	16	12	0.93	0.64	8.8	1.3	10	0.044	0.091	1.5	0.028	0.35	11	1.3	22	6.6	<0.05	0.025
	Median	29	16	12	1.2	0.89	9.9	1.9	11	0.055	0.12	1.7	0.046	0.48	12	1.3	25	7.1	<0.05	0.095

		Cereal products	Pastries	*Pizza, hand pie*	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
	Max	34	16	15	1.8	0.92	17	3.0	12	0.061	0.13	2.6	0.066	0.51	14	2.2	30	8.1	<0.05	0.096
Hg	Mean	0.96	<0.35	0.23	<0.35	<0.35	29	20	0.24	<0.2	<0.35	<0.2	2.4	<0.35	<0.35	<0.35	<0.35	<0.35	<0.2	<0.2
(µg/kg)	Min	0.69	<0.35	0.17	<0.35	<0.35	22	17	0.17	<0.2	<0.35	<0.2	2.2	<0.35	<0.35	<0.35	<0.35	<0.35	<0.2	<0.2
	Median	1.0	<0.35	0.17	<0.35	<0.35	31	19	0.17	<0.2	<0.35	<0.2	2.3	<0.35	<0.35	<0.35	<0.35	<0.35	<0.2	<0.2
	Max	1.2	<0.35	0.35	<0.35	<0.35	34	23	0.39	<0.2	<0.35	<0.2	2.5	<0.35	<0.35	<0.35	<0.35	<0.35	<0.2	<0.2
Ni	Mean	246	253	85	58	43	25	16	285	5.6	10	351	1.3	11	109	156	65	559	8.2	11
(µg/kg)	Min	234	213	81	11	17	21	9.3	213	2.2	7.1	221	1.0	9.2	83	116	59	504	2.0	9.3
	Median	243	270	83	19	19	26	16	279	2.5	10	242	1.0	12	101	169	60	539	3.0	11
	Max	260	277	93	144	93	28	23	363	12	12	591	2.0	12	144	182	77	633	20	13
Pb	Mean	1.9	2.6	2.7	1.3	1.1	1.0	0.61	3.6	<0.5	0.94	0.88	0.18	0.46	2.4	1.4	0.74	3.2	0.34	0.51
(µg/kg)	Min	1.2	1.7	2.4	0.67	0.61	0.5	0.45	3.3	<0.5	0.73	0.76	0.15	0.28	1.4	1.3	0.69	3.0	0.25	0.25
	Median	2.1	2.6	2.6	0.75	1.2	0.81	0.47	3.6	<0.5	0.81	0.77	0.15	0.43	1.8	1.5	0.72	3.3	0.25	0.51
	Max	2.5	3.4	2.9	2.3	1.3	1.4	0.91	3.9	<0.5	1.3	1.1	0.26	0.68	4.0	1.5	0.81	3.4	0.52	0.77

8.5.2 Exposure estimations and time trends

Estimated mean intakes of the metals in the Swedish population (per capita intakes) are shown in Table 19. The proportional contribution of each food group to the per capita intakes are presented in Figure 18. The food group cereal products was an important contributor for most of the analysed metals. For mercury and total arsenic, fish was by far the greatest contributor. Figure 19 illustrates changes in estimated per capita intake of metals in market basket studies since 1999. Per capita intakes in 1999, 2005, and 2010 were estimated by pooled samples analysed in year 2017. Concentrations were analysed in one pooled sample per food group and market basket study.

Arsenic (As)

Fish was the largest contributor to total arsenic exposure, with lean fish contributing 77% and fatty fish contributing 20% to the exposure. Cereals were the largest contributor to exposure for inorganic arsenic, accounting for 64% of the exposure. The present calculated intake of total arsenic (tAs) was 102 µg/day. As for inorganic arsenic, the estimated exposure was 0.047 µg/kg bw/day. This is higher than what was calculated for the Market basket 2015, and is in line with exposure estimates for the European population by EFSA (EFSA et al., 2021). Mean dietary exposure estimates for inorganic arsenic ranged from 0.03 to 0.15 µg/kg bw/day (min LB–max UB) for adults.

Aluminium (Al)

Vegetables were the main contributor to exposure, contributing around 23 % of the total exposure. The present calculated intake of aluminium was 32 µg/kg bw/ day or 0.22mg/kg bw/week. In EFSAs estimate the daily dietary exposure to aluminium in the general population, across several European countries, varied from 0.2 to 1.5 mg/kg bw/week (mean) and was up to 2.3 mg/kg bw/week for highly exposed consumers (EFSA, 2008b). The estimate from this Market basket is in the lower end of the range. Based on results from market basket studies aluminium exposure has remained relatively unchanged since 1999 with the exception of 2010 for which we do not have an explanation.

Silver (Ag)

Cereals were the main contributor to exposure, contributing around 30 % of the total exposure. The present calculated intake of silver was 0.66 µg/person/ day. This is lower than previous market baskets. This is also lower than what EFSA estimated based on a TDS from ANSES. For adults, the mean exposure ranged from 1.29 µg/kg bw/day (lower bound) to 2.65 µg/kg bw/day (upper bound) (EFSA, 2016b).

Cadmium (Cd)

Cereals were the main contributor to exposure, accounting for around 42 % of the total exposure the other main contributors are potatoes (23%) and vegetables (20%). The present calculated intake of cadmium was 16 µg/person/ day or 1.6 µg/kg bw/week. This exposure is higher than in previous market baskets. Part of the explanation for this difference can be explained by higher Cd concentrations in the main contributors, i.e. cereals, vegetables, and potatoes. Another part of the explanation was a higher consumption of vegetables and potatoes. This estimate is however in line with the medium bound exposure estimate for Swedish adults from EFSA 1.77 µg/kg bw/week (EFSA, 2012a).

Mercury (Hg)

Fish was the main contributor to the exposure contributing around 74% of the total exposure. The present calculated intake of Mercury was 1.1 µg/person/ day or 0,11 µg/kg bw/week. This estimate is the lowest we have measured in any market basket study. The estimate is in line with but lower than the EFSA medium bound assessment of methylmercury from 2012 with a median of 0.24 µg/kg bw/ week for adults(EFSA, 2012e).

Nickel (Ni)

The largest contributor to the exposure was cereals contributing around 28% of the total exposure. The present calculated intake of nickel was 208 µg/person/ day, or 3 µg/kg bw/ day. This is in line with the exposure estimates from EFSA for the European general population, that range from 2.9 to 3.4 µg/kg bw/ day for adults (EFSA et al., 2020a). There was no clear trend in the per capita exposure estimates from earlier market baskets but the estimates from 2015 and 2022 were lower than previous estimates.

Lead (Pb)

Vegetables were the main contributor to exposure, accounting for around 24% of the total exposure. Cereals also contributed about 18% to exposure. The present calculated intake of lead was 0.036 µg/kg bw/ day. This is the lowest lead exposure level measured in the Market basket since measurements started in 1999. It is also lower than the exposure estimate from EFSA of 0.50 µg/kg bw/ day for the general adult population of Europe (EFSA, 2012c). Most of the food groups had levels half of what was measured in 2015 and for sugar and sweets the level of lead decreased from 11 µg/kg to 3.2 µg/kg. A lower level of exposure fits with the observation that has emerged from monitoring of lead in blood. A trend towards lower amounts in blood has been seen since the phase out of leaded gasoline in Sweden (Stajnko et al., 2024).

Table 19. Mean daily intake of metals from food groups and total intake in the Market Basket 2022 (N=3 per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)							
			Ag	Al	tAs	iAs	Cd	Hg	Ni	Pb
Cereal products	226	HB	0.20	345	3.1	2.1	6.7	0.21	56	0.44
		LB						0		
Pastries	55	HB	0.017	171	0.21	NA	0.91	0	14	0.15
		UB						0.20		
		LB						0.0013		
Pizza, hand pie[1]	11	HB	0.0043	58	0.042	NA	0.15	0.0026	0.98	0.029
		UB						0.0026		
		LB	0					0		
Meat	194	HB	0	86	0.54	NA	0.26	0	11	0,25
		UB	0.047					0.068		
		LB	0					0		
Processed meat[1]	48	HB	0	45	0,13	NA	0.039	0	2.1	0.050
		UB	0.011					0.017		
		LB				0				
Lean fish	15	HB	0.17	7.4	75	0	0.18	0.45	0.39	0.015
		UB				0.15				
		LB	0.0047			0				
Fatty fish	18	HB	0.0054	5.0	20	0	0.038	0.36	0.29	0.011
		UB	0.0062			0.18				
		LB	0.00065					0		0.046
Meat substitutes	3	HB	0.0009	20	0.021	0.0098	0.034	0	0.86	0.091
		UB	0.0011					0.053		0.13
		LB	0	17				0		0
Lean dairy products	248	HB	0	25	0.33	NA	0.013	0	1.4	0
		UB	0.013	30				0.050		0.13
		LB	0					0		
Fatty dairy products	70	HB	0	17	0.65	NA	0.0084	0	0.71	0.067
		UB	0.017					0.025		
		LB	0					0		
Plant-based drinks	13	HB	0	12	0.040	0.021	0.025	0	4.6	0.011
		UB	0.00065					0.0026		
Eggs	29	LB	0	0	0.20	NA	0.0014	0.068	0.020	0.0026

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)							
			Ag	Al	tAs	iAs	Cd	Hg	Ni	Pb
		HB	0	0					0.039	0.0055
		UB	0.069	2.6					0.039	0.0084
		LB	0					0		
Fats and oils	55	HB	0	17	0.23	NA	0.025	0	0.64	0.026
		UB	0.0027					0.020		
		LB						0		
Vegetables	245	HB	0.064	456	0.55	0.33	3.2	0	27	0.60
		UB						0.084		
		LB	0.020					0		
Fruits	215	HB	0.037	305	1.0	0.62	0.34	0	34	0.31
		UB	0.055					0.077		
		LB						0		
Potatoes	142	HB	0.14	89	0.34	NA	3.7	0	9.3	0.11
		UB						0.050		
		LB	0					0		
Sugar and sweets	74	HB	0	328	0.38	0.18	0.54	0	41	0.24
		UB	0.018					0.026		
		LB	0	15			0	0		0.046
Beverages	262	HB	0	17	0.20	NA	0	0	2.2	0.091
		UB	0.063	20			0.013	0.053		0.13
		LB	0		0.07		0.029	0	4.7	0.18
Coffee and tea	407	HB	0	325	0.14	NA	0.029	0		0.21
		UB	0.020		0.2		0.033	0.084		0.25
		LB	**0.61**	**2225**	**102**	**3.3**	**16**	**1.1**	**208**	**2.5**
Total		**HB**	**0.63**	**2236**	**102**	**3.3**	**16**	**1.1**	**208**	**2.7**
		UB	**0.91**	**2242**	**102**	**3.6**	**16**	**1.9**	**208**	**2.9**
µg/kg bw/day		**HB**	**0.0089**	**32**	**1.5**	**0.047**	**0.23**	**0.016**	**3**	**0.036**

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects). Pizza/hand pie and processed meat are subgroups of pastries and meat, respectively, and their intakes are included in pastries and meat. The subgroups are therefore not included when calculating total per capita intake. A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

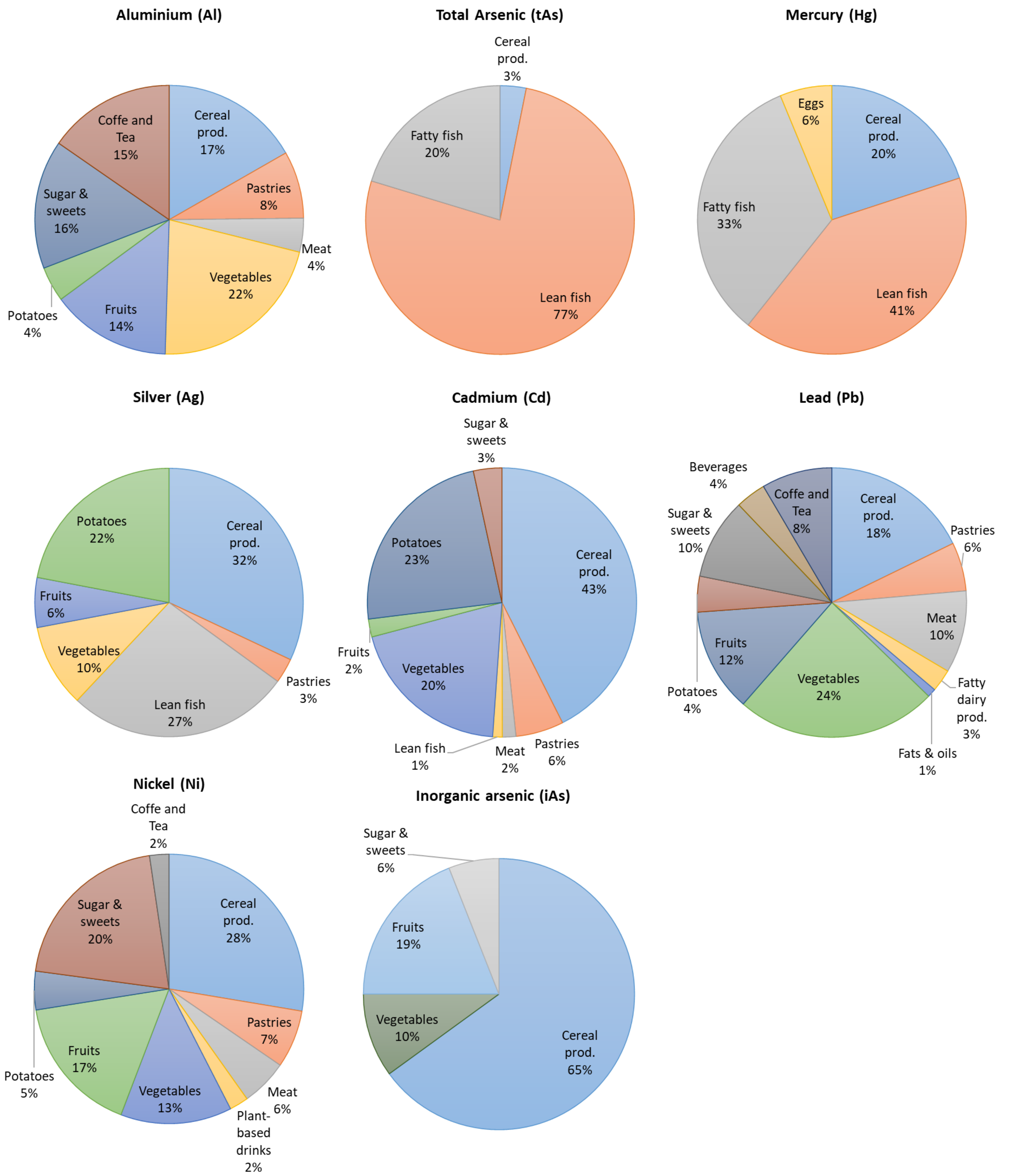

Figure 18 . Percentage contribution to the per capita intake of metals (Al, tAs, iAS, Hg, Ag, Cd, Pb and Ni) from different food groups in the Market Basket 2022.

Food groups contributing less than 1% to the intake are not included in the pie charts. The percentage is based on mean per capita intake per food group. Hybrid bound was used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

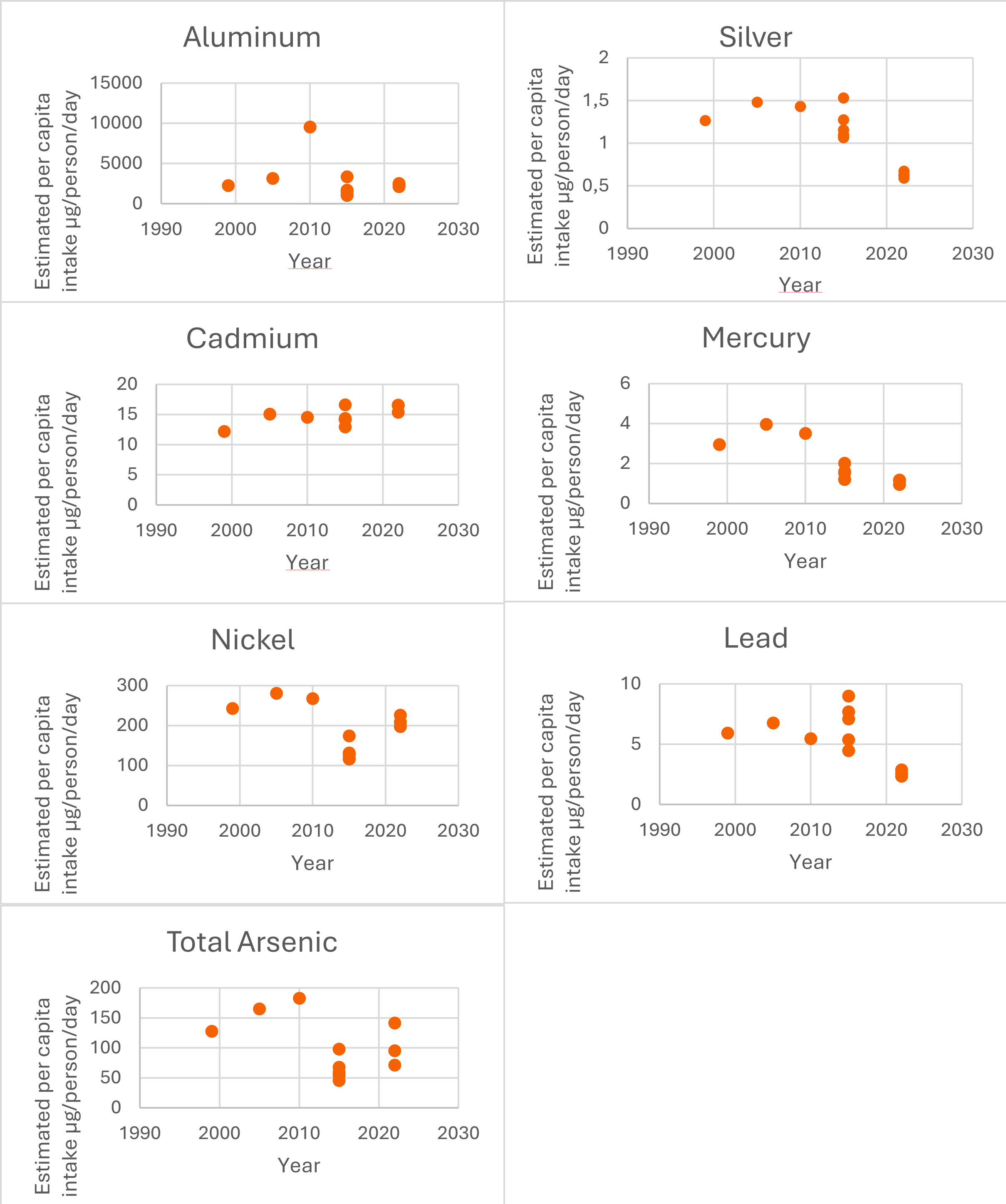

Figure 19. Estimated per capita intake of metals in market basket studies over time.

Note, that the per capita intake is a function of per capita consumption and compound concentrations in the food groups. Intake from coffee and tea is not included. Number of samples per food group was: N=1 (1999), N=1 (2005), N=1 (2010), N=5 (2015), N=3 (2022). Concentrations were analysed in one pooled sample per food group and market basket study. It is possible that loss of water content and other factors have affected the analysed concentrations of these samples, which must be kept in mind when interpreting these time trends. No statistical testing of time trends was done due to the low number of observations.

8.5.3 Risk assessment

The risk assessment and characterization is mainly a comparison of exposure levels in relation to health-based guidance values (HBGV) (Figure 20). Some of the HBGVs are tolerable weekly intakes (TWIs) such as for aluminium, cadmium and mercury, others are reference points like for lead and arsenic. It should be noted that there are many variations of important variables that affect the exposure and the risk across the population that are not taken into account, such as differences in body weight, consumption patterns and differences in concentrations *within* the food groups. This exposure estimate is only for an average consumer.

Arsenic (As)

We are exposed to arsenic in both organic and inorganic forms. The inorganic form (iAs) mainly occurs as trivalent (arsenite) and pentavalent (arsenate). Water, cereals, and rice primarily contain the inorganic arsenic, which is the most toxic form for humans. Other foods, mainly fish and shellfish, may contain high levels of the organic forms, such as arsenobetaine and arsenic sugar compounds, which, are considered to be less toxic (Swedish Food Agency and Sand, 2022).

EFSA has established a reference point for inorganic arsenic of 0.06 µg iAs/kg/day based on a 5% increased relative risk of skin cancer. The reference point should also be protective against bladder cancer, lung cancer, spontaneous abortion, stillbirth, infant mortality, and effects on the developing nervous system (EFSA et al., 2024a).

The calculated intake of inorganic arsenic was 0.047 µg/kg bw/ day. This is close to the EFSA reference point of 0.06 µg iAs/kg/day. In the most recent EFSA opinion, MOEs for adult average and high consumer exposures range between 2-0.4 and between 0.86-0.18, respectively, indicating that this raises a concern for skin cancer.

Aluminium (Al)

Aluminium is neurotoxic in patients undergoing dialysis. These patients are chronically exposed to high levels of aluminium. In 2008, EFSA established a TWI of 1 mg/kg bw/week based on effects on the developing nervous system (EFSA, 2008b). The present calculated intake of aluminium was 0.2 mg/kg bw/week. This represents 20% of the TWI.

Silver (Ag)

Pigmentation of the eye is considered to be the first sign of generalized argyria, in which the skin turns a bluish grey color. WHO (World Health Organization, 2003) considers that a total lifetime oral exposure of about 10 g of silver can be considered as the human no-observed-adverse effect level (NOAEL) based on argyria. This translates to a daily exposure to 0.4 mg/day (for 70 years). The present calculated intake of silver was 0.66 µg/person/ day. This corresponds to 0.17% of the NOAEL. Cereals were the main contributor, accounting for about 30% of the exposure. This exposure is well below the NOAEL, and the health concern can be considered very low.

Cadmium (Cd)

Cadmium is toxic to the kidney, where it accumulates over time and may cause renal dysfunction. In addition, osteoporosis, cardiovascular effects, cancer, sperm motility and cognitive effects in children have been attributed to Cd exposure (Wallin et al., 2016, Borne et al., 2015, Satarug et al., 2017, Engstrom et al., 2011, Larsson et al., 2015). EFSA established a TWI in 2009 based on effects on the kidney. A critical urinary concentration of 1 µg/g creatinine was converted to a TWI of 2.5 µg/kg bw based on 50 years of exposure.

The present calculated intake of cadmium was 1.6 µg/kg bw/week. This represents 64% of the TWI. The low margin to the TWI means it is likely that some consumers will exceed it. It would be desirable to lower exposure to cadmium.

Mercury (Hg)

Mercury occurs in different chemical forms, inorganic mercury, and methyl mercury, with different toxicological profiles. EFSA established a TWI of 1.3 µg/kg bw/week for methyl mercury and a TWI of 4 µg/kg bodyweight/week for inorganic mercury based on developmental effects on the brain(EFSA, 2012e).

The present calculated intake of mercury was 0.11 µg/kg bw/week corresponding to 8.4% of the TWI for methyl mercury. To estimate the exposure to methyl mercury more exactly, only exposure from fish and eggs was considered. A 1:1 conversion of mercury to methylmercury was assumed for these categories similar to what was done in the EFSA opinion. All other categories were regarded as inorganic mercury. This gives an exposure of 0.087 µg/kg bw/week or 6.7% of the TWI for methyl mercury. Most consumers are likely to be well under the TWI. This is also supported by biomonitoring data on Swedish adolescents (Swedish Food Agency and Swedish Environmental Protection Agency, 2020), where a median blood level of 0.72 µg/l was seen. When comparing this to the blood mercury concentration equivalent of the TWI, which is 23 µg/l, the average blood mercury level was found to be 3.1% of this threshold. This estimate applies to the average consumer only. It cannot be ruled out that certain consumers eating a high amount of certain fish species have a different risk profile.

If the remaining mercury, mainly from cereals, is considered inorganic mercury this gives an exposure of 0.022 µg/kg bw/week. This corresponds to 0.54% of the TWI for inorganic mercury.

Nickel (Ni)

A tolerable daily intake (TDI) of 13 µg/kg bw based on an increased incidence of post-implantation loss in rat was determined by EFSA. They also note that persons that are nickel-sensitized may develop eczematous flare-up reactions in the skin from oral exposure (EFSA et al., 2020a). This is an acute effect and the LOAEL of 4.3 µg Ni/kg bw was selected as the reference point.

The present calculated intake of nickel was 3 µg/kg bw/ day. This represents 23% of the TDI or 69% of the reference point (RP) set for acute effects on nickel-sensitized individuals. The

RP or 4.3 µg Ni/kg bw, translates to 301 µg Ni/day for a 70 kg person. This level of exposure could be achieved by drinking vegan drinks alone. A nickel sensitized individual only needs to drink less than 3 dl of such drinks (all other consumption held constant) in order to exceed the acute reference dose. The fraction of nickel sensitized individuals in Sweden is low compared to other European countries due to legislation implemented in 1990. However, prevalence is still around 8% (Schuttelaar et al., 2018).

Lead (Pb)

EFSA have established a RP for adults of 0.63 µg/kg bw/day for chronic kidney disease, and a RP of 1.5 µg/kg bw/day for effects on systolic blood pressure (EFSA, 2010a). For children, EFSA has determined a RP of 0.5 µg/kg bw/day based on neurotoxic effects. These reference points are based on blood lead levels of 15 µg/l, 36 µg/l, and 12 µg/l, respectively. 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.

The present calculated intake of lead was 0.036 µg/kg bw/ day. This represents 5.4% of RP for adults. This was lower than the previous market basket survey. There is a trend toward lower levels lead in blood since leaded gasoline was phased out (Stajnko et al., 2024). However, blood levels are still close to the RP. In the recent Riksmaten survey median blood lead levels among adolescents were 7.1 µg/l and 16.32 µg/l in the 95^{th} percentile so a reduction in lead exposure is still desirable (Swedish Food Agency and Swedish Environmental Protection Agency, 2020).

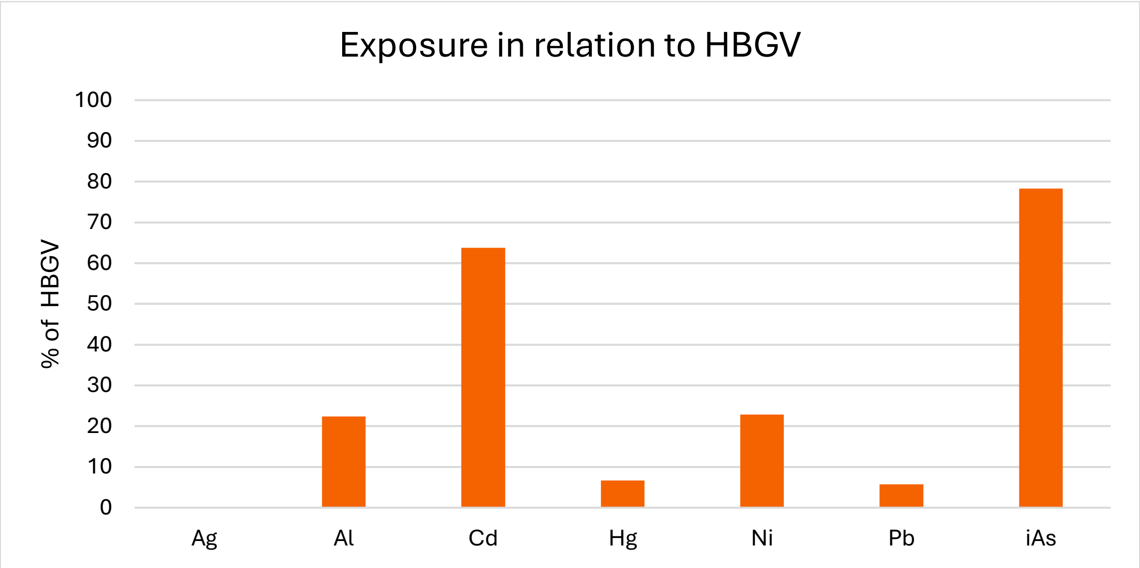

Figure 20. Estimated per capita intake in the Market Basket 2022 in relation to health-based guidance values (HBVG).

For lead the reference point for adults, of 0.63 µg/kg bw/day for chronic kidney disease is used. For mercury the exposure is calculated from methyl mercury estimation and the tolerable weekly intake of 1.3 µg/kg bw/day is used.

8.5.4 Conclusion

Analytical sensitivity did not significantly impact the total exposure levels. There was very little difference between the upper, lower and hybrid bound estimates.

Exposure calculations of all of the metals were below the HBGVs. Some were, however, close, mainly for cadmium and inorganic arsenic. These compounds continue to be a cause for concern. Inorganic arsenic was much closer to the HBGV in this market basket than in the Market Basket 2015. This is mainly due to the updated reference point for arsenic, which is established more in line with what is considered an acceptable cancer incidence. The effect is also partly due to increased exposure.

New food groups in this market basket study are meat substitutes, and plant-based drinks. Interestingly, meat substitutes had the highest level of aluminium and lead. And plant-based drinks had a high level of nickel. Currently they do not contribute much to the overall exposure since they only comprise a small part of the total consumption. For certain individuals however these products might contribute significantly to exposure. In addition, if these products become more popular in the future this might become more significant.

8.6 PCBs and dioxins

Polychlorinated biphenyls (PCBs) are industrial chemicals that used to have multiple areas of use while dioxins, i.e. polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), are formed as by-products during different industrial processes and incomplete combustion (Erickson and Kaley, 2011, Rappe, 1996). Although the production, use and/or emission of PCBs and dioxins have been strongly regulated since the 1970s they are still found in the environment and in humans due to their persistence to degradation. Food is the main source of human exposure to PCBs and dioxins. Because of their lipid solubility and persistence, they bioaccumulate throughout the food webs and food of animal origin contain the highest levels.

In the Market Basket 2022, PCBs and PCDD/Fs were analysed in seven selected food groups that are known to contribute most to exposure, i.e. meat, lean and fatty fish, lean and fatty dairy products, eggs, and fats/oils. In addition, the compounds were analysed in meat substitutes and plant-based drinks since these food groups were not included in previous market baskets and levels of PCBs and PCDD/Fs in these products on the Swedish market are mainly unknown.

The chemical analyses were performed at the Swedish Food Agency, and the analytical method is described in Appendix 4 (section A 4.5). Briefly, PCDD/Fs and PCBs were extracted using either liquid-liquid-extraction or pressurized liquid extraction with different solvent mixtures depending on sample type. Clean-up and fractionation were performed before final determination using GC-HRMS with isotopic dilution technique. Six non dioxin-like (ndl) PCBs (CB 28, 52, 101, 138, 153, 180), the 12 dioxin-like (dl) PCBs (CB 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189) and the 17 toxic 2,3,7,8-chloro-substituted PCDD/Fs were determined. The LOQ varied between food groups and samples and was determined for the individual congeners in each sample. On fresh weight basis, LOQs for ndl-PCBs varied between 0.00001 and 0.05 ng/g, between 0.0003 and 23 pg/g for dl-PCBs and between 0.0001 and 0.86 pg/g for PCDD/F congeners.

8.6.1 Concentrations in food groups

Concentrations of all analysed PCBs and PCDD/Fs in all food groups and samples are presented in Appendix 5 (section A 5.3) and the results are summarized and compiled in Table 20 and Table 21. For the ndl-PCBs, concentrations of CB 153 and the sum of indicator PCBs, i.e. CB 28, 52, 101, 138, 153 and 180, are presented (Table 20). The sums of dl-PCB and PCDD/F concentrations are expressed as toxic equivalents (TEQ) using the toxicity equivalency factors (TEFs) set by WHO in 2005 (Van den Berg et al., 2006) (TEQ_{2005}, Table 20) and 2022 (DeVito et al., 2024) (TEQ_{2022}, Table 21). In the calculations of the sum of indicator PCBs and the TEQs, concentrations below LOQ were either set to zero (lower bound, LB), to LOQ divided by 2 (medium bound, MB) or to LOQ (upper bound, UB).

Concentrations of both indicator PCBs, dl-PCB TEQ_{2005} and PCDD/F TEQ_{2005} were highest in fatty fish, followed by fats/oils and fatty dairy products. The concentrations were lower in eggs, lean fish and meat and generally lowest in meat substitutes, lean dairy products, and plant-based drinks. The contribution of dl-PCB TEQs and PCDD/F TEQs to the total-TEQ_{2005} (sum of dl-PCB TEQ_{2005} and PCDD/F TEQ_{2005}) varied between food groups. In meat, lean fish, fatty fish and lean dairy products, dl-PCB TEQ_{2005} contributed with ca 60-70% to the total-TEQ_{2005}, while PCDD/F TEQ_{2005} dominated in fatty dairy products and fats/oils. In eggs, dl-PCB TEQ_{2005} and PCDD/F TEQ_{2005} contributed with about 50% each.

The WHO TEFs from 2022 have not been fully implemented yet. For example, current maximum levels established by the EU and the tolerable weekly intake (TWI) determined by EFSA are based on TEFs from 2005. The TEQ_{2022}-concentrations in Table 21 are accordingly presented mostly for comparison and for future use. The total-TEQ concentrations are lower when the 2005 TEFs are replaced by the 2022 TEFs, mainly because of lower TEFs of the dl-PCBs, leading to lower dl-PCB TEQs. Levels of dl-PCB TEQ_{2022} and PCDD/F TEQ_{2022} were highest in fatty fish, fatty dairy products and fats/oils. In fatty fish and lean dairy products, dl-PCB TEQ_{2022} contributed with more than 50% to the total-TEQ_{2022}. PCDD/F TEQ_{2022} dominated in the other food groups, contributing with more than 80% to the total-TEQ_{2022} in fatty dairy products and fats/oils and with ca 50-70% in meat, lean fish and eggs.

Table 20. Concentrations of PCBs and dioxins (PCDD/F) (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 per food group). Sums (indicator-PCB, dl-PCB-TEQ2005, PCDD/F-TEQ2005 and total-TEQ2005) were calculated using the medium (MB), lower (LB) and upper (UB) bound methods. Mean, min, median and max are given for the medium bound approach, with lower and upper bound in parenthesis. The TEFs set by WHO in 2005 (Van den Berg et al., 2006) were used to calculate TEQ (TEQ2005).

		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
Fat	Mean	6.7	1.7	11	5.8	1.6	22	2.1	8.1	60
(%)	Min	5.0	1.5	11	4.2	1.5	21	1.9	7.6	60
	Median	6.9	1.6	11	6.4	1.6	22	2.1	8.2	60
	Max	8.0	2.1	12	6.8	1.6	22	2.3	8.5	61
CB 153	Mean	30	39	857	0	3	53	0	44	43
(ng/kg)	Min	26	27	660	<3	3	43	<0.2	37	27
	Median	32	44	860	<5	3	54	<0.3	42	49
	Max	33	45	1050	<10	4	61	<0.4	53	52
indicator-	Mean	70 (63-76)	105 (90-114)	2383 (2383-2383)	23 (10-35)	7.3 (6.7-7.7)	133 (115-150)	1.2 (0-2)	97 (87-107)	143 (106-183)
PCB[1]	Min	64 (56-71)	65 (49-81)	1870 (1870-1870)	12 (1-23)	6 (6-7)	110 (96-130)	0.6 (0-1)	84 (74-94)	110 (80-140)
(ng/kg)	Median	72 (65-79)	120 (100-130)	2350 (2350-2350)	21 (8-34)	7 (6-7)	140 (120-150)	1 (0-2)	87 (76-97)	150 (110-200)
	Max	73 (67-79)	130 (120-130)	2930 (2930-2930)	35 (20-49)	9 (8-9)	150 (130-170)	2 (0-3)	120 (110-130)	170 (130-210)
dl-PCB-	Mean	13 (12.7-12.7)	15 (15.0-15.3)	230 (230-230)	1 (0.0-2)	2.3 (2.3-2.3)	37 (37.3-37.3)	0.3 (0.0-0.8)	18 (18.3-18.3)	28 (27-28)
TEQ_{2005}[2]	Min	11 (11-11)	10 (10-10)	180 (180-180)	1 (0-2)	2 (2-2)	35 (35-35)	0.3 (0.0-0.6)	14 (14-14)	20 (20-21)
(pg TEQ/kg)	Median	13 (13-13)	17 (17-18)	220 (220-220)	1 (0-2)	2 (2-2)	38 (37-38)	0.3 (0.0-0.7)	14 (14-14)	28 (27-28)
	Max	14 (14-14)	18 (18-18)	290 (290-290)	1 (0.0-2)	3 (3-3)	39 (39-39)	0.4 (0.0-1)	27 (27-27)	36 (35-36)
PCDD/F-	Mean	10 (4-17)	9 (2-16)	107 (85-133)	9 (2-16)	1.0 (0.2-2.3)	70 (61-82)	1.0 (0.0-2.3)	19 (14-23)	84 (62-105)
TEQ_{2005}[3]	Min	9 (0-15)	7 (1-14)	100 (80-120)	7 (0.4-14)	1 (0.0-2)	29 (10-49)	1 (0.0-2)	14 (10-18)	42 (18-66)
(pg TEQ/kg)	Median	10 (5-16)	9 (1-17)	100 (83-130)	10 (2-15)	1 (0.2-2)	71 (64-77)	1 (0.0-2)	17 (14-19)	81 (57-110)
	Max	11 (7-19)	11 (4-18)	120 (93-150)	11 (5-19)	1 (0.5-3)	110 (110-120)	1 (0.0-3)	25 (19-31)	130 (110-140)
total-	Mean	23 (17-29)	24 (17-32)	340 (320-363)	10 (2-18)	3.7 (3-4.7)	109 (96-119)	1.7 (0.0-3)	37 (33-41)	114 (90-132)
TEQ_{2005}[4]	Min	22 (13-26)	17 (11-24)	290 (270-310)	8 (0.4-15)	3 (3-4)	68 (49-88)	1 (0.0-3)	31 (28-33)	63 (38-87)
(pg TEQ/kg)	Median	22 (18-30)	27 (19-35)	320 (300-340)	11 (2-17)	4 (3-5)	110 (99-110)	2 (0.0-3)	39 (33-45)	120 (93-140)
	Max	24 (19-32)	28 (21-36)	410 (390-440)	12 (5-22)	4 (3-5)	150 (140-160)	2 (0.0-3)	41 (37-46)	160 (140-170)

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

[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 congeners.

[4] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.

Table 21. Concentrations of dl-PCBs and dioxins (PCDD/F) (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 per food group). Sums (dl-PCB-TEQ2022, PCDD/F-TEQ2022 and Total-TEQ2022) were calculated using the medium (MB), lower (LB) and upper (UB) bound methods. Mean, min, median and max are given for the MB approach, with LB and UB in parenthesis. The TEFs set by WHO in 2022 (DeVito et al., 2024) were used to calculate TEQ (TEQ2022).

		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
dl-PCB-TEQ_{2022}[1] (pg TEQ/kg)	Mean	6.4 (6.3-6.6)	7.8 (7.8-7.9)	122 (122-122)	0.6 (0.0-1.1)	1.2 (1.2-1.2)	19 (19-19)	0.2 (0.0-0.4)	9.4 (9.2-9.6)	14 (13-15)
	Min	5 (5-6)	5 (5-5)	96 (96-96)	0.4 (0-1)	1 (1-1)	18 (18-18)	0.2 (0.0-0.3)	7 (7-7)	11 (10-11)
	Median	7 (7-7)	9 (9-9)	116 (116-116)	0.6 (0-1)	1 (1-1)	19 (19-19)	0.2 (0.0-0.4)	7 (7-7)	14 (13-15)
	Max	7 (7-7)	9 (9-9)	155 (155-155)	0.7 (0.0-1)	1 (1-1)	20 (20-20)	0.3 (0.0-0.5)	14 (14-14)	18 (17-19)
PCDD/F-TEQ_{2022}[2] (pg TEQ/kg)	Mean	11 (5-17)	8.8 (2.5-15)	81 (62-100)	8.5 (2.5-15)	0.9 (0.1-1.7)	80 (70-89)	1.1 (0.0-2.2)	19 (16-22)	90 (69-110)
	Min	9 (0.0-16)	7 (2-13)	74 (57-90)	8 (0.3-13)	1 (0.0-2)	32 (13-50)	1 (0.0-2)	14 (11-16)	35 (12-57)
	Median	11 (5-17)	9 (3-15)	84 (65-102)	9 (1-15)	1 (0.1-2)	87 (83-91)	1 (0.0-2)	14 (11-17)	115 (94-136)
	Max	13 (9-18)	10 (3-17)	87 (66-108)	9 (6-16)	1 (0.2-2)	121 (115-127)	1 (0.1-3)	28 (25-31)	119 (101-137)
total-TEQ_{2022}[3] (pg TEQ/kg)	Mean	17 (11-24)	17 (10-23)	204 (185-223)	9.1 (2.5-16)	2.1 (1.3-2.9)	99 (89-109)	1.3 (0.0-2.6)	28 (25-31)	104 (83-125)
	Min	16 (7-23)	13 (7-18)	180 (162-198)	8 (0.3-14)	2 (1-3)	51 (33-70)	1 (0.0-2)	21 (18-24)	45 (22-69)
	Median	18 (12-23)	18 (12-25)	190 (173-207)	9 (1-16)	2 (1-3)	105 (100-109)	1 (0.0-3)	28 (24-31)	133 (111-152)
	Max	19 (14-25)	19 (12-26)	241 (219-263)	10 (6-17)	2 (1-3)	140 (134-147)	2 (0.1-3)	35 (32-39)	133 (115-155)

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

[2] Sum TEQ of 17 PCDD/F congeners.

[3] Sum TEQ of 17 PCDD/F and 12 dioxin-like PCB congeners.

8.6.2 Exposure estimations and time trends

Estimated mean intakes of CB 153, total-TEQ_{2005} and total-TEQ_{2022} in the Swedish population (per capita intakes) are presented in Table 22 and the contribution of each food group to the per capita intakes of CB 153 and total-TEQ_{2005} are presented in Figure 21.

Table 22. Mean daily intake of CB 153 (ng/day), total-TEQ2005 and total-TEQ2022 (pg TEQ/day) from different food groups and total intake in the Market Basket 2022 (N=3 samples per food group). For the total intake, min and max is presented (in parenthesis) in addition to the mean.

Food group	Per capita consumption (g/day)		Per capita intake CB 153 (ng/day)	total-TEQ_{2005} (pg TEQ_{2005}/day)	total-TEQ_{2022} (pg TEQ_{2022}/day)
Meat	194	LB		3.2	2.1
		MB	5.9	4.4	3.3
		UB		5.7	4.6
Lean fish	15	LB		0.3	0.2
		MB	0.6	0.4	0.2
		UB		0.5	0.3
Fatty fish	18	LB		5.8	3.3
		MB	15	6.1	3.7
		UB		6.5	4.0
Meat substitutes	3	LB	0	0.01	0.01
		MB	0.01	0.03	0.03
		UB	0.02	0.05	0.05
Lean dairy products	248	LB		0.7	0.3
		MB	0.8	0.9	0.5
		UB		1.2	0.7
Fatty dairy products	70	LB		6.7	6.2
		MB	3.7	7.7	6.9
		UB		8.4	7.6
Plant-based drinks	13	LB	0	0.0001	0.001
		MB	0.002	0.02	0.02
		UB	0.004	0.04	0.03
Eggs	29	LB		0.9	0.7
		MB	1.3	1.1	0.8
		UB		1.2	0.9
Fats and oils	55	LB		5.0	4.6
		MB	2.3	6.3	5.7
		UB		7.3	6.9
Total		**LB**	**30 (27-33)**	**23 (17-27)**	**17 (10-24)**
		MB	**30 (27-33)**	**27 (21-31)**	**21 (15-27)**
		UB	**30 (27-33)**	**31 (26-35)**	**25 (19-30)**
ng or pg/kg body weight/day		**MB**	**0.43 (0.39-0.47)**	**0.39 (0.30-0.44)**	**0.30 (0.21-0.39)**

LB, lower bound (i.e. 0 is used for <LOQ); MB, medium bound (i.e. 0.5*LOQ is used for <LOQ); UB, upper bound (i.e. LOQ is used for <LOQ). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

Most samples had concentrations of CB 153 above LOQ, giving identical LB, MB and UB per capita total intakes (Table 22). For PCDD/Fs and dl-PCBs, there were congeners with a large proportion of concentrations below LOQ, and the UB total-TEQ_{2005} per capita intake was 35% higher than the LB intake. The total per capita intake of CB 153 and total-TEQ_{2005} varied about 20 and 50%, respectively between the three grocery chains.

Fatty fish contributed to about half of the total intake of CB 153, with meat and fatty dairy products as second most important food groups (Figure 21). Fish was important also for the total-TEQ_{2005} intake, but in this case, the contributions from fatty fish, fatty dairy products and fats/oils were similar (23-28%) and meat was on the fourth place with a contribution of 16%. Using the 2022 TEFs, the contribution from fatty fish decreased to 17% and the contribution from fatty dairy products and fats/oils increased slightly.

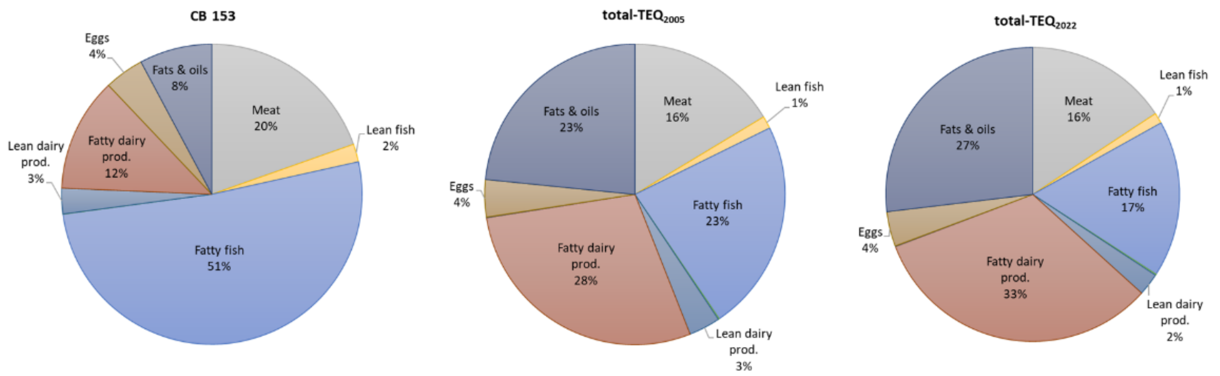

Figure 21. Percentage contribution to the per capita intake of CB 153, total-TEQ2005 and total-TEQ2022 (sum of dl-PCB TEQ and PCDD/F TEQ) from food groups in the Market Basket 2022.

Food groups contributing less than 1% (plant-based drinks and meat substitutes) are only presented graphically in the pie chart, and not with text. The percentages are based on mean per capita intake per food group. When calculating the mean, medium bound (MB) concentrations (0.5*LOQ) were imputed for concentrations below LOQ.

The contribution of different food groups to the total-TEQ_{2005} intake differed between the Market Basket 2015 (Swedish Food Agency, 2017) and 2022. The contribution from fish and eggs has decreased considerably, from 41 to 23% and from 18 to 4%, respectively. One explanation is decreased concentrations of dl-PCBs and PCDD/Fs in these food groups. The mean MB total-TEQ_{2005} concentration in fish was 296 pg TEQ/kg in 2015 and 198 pg TEQ/kg in 2022 (a fictive total fish food group with 55% fatty fish and 45% lean fish). Corresponding concentrations in eggs were 194 and 37 pg TEQ/kg. In addition, the estimated per capita consumption of fish in 2022 (33 g/day) was lower than in 2015 (46 g/day). Another data source for fish consumption was used in 2022 compared to previous market basket studies (see section 8.1). The fish consumption estimated in line with previous studies was 37 g/person/day. However, increasing the daily per capita fish consumption in the calculations to 37 g/day (20 g fatty fish and 17 g lean fish) only increased the contribution of fish to the total total-TEQ_{2005} intake to 26%. Because of the decreased intake from fish and eggs and because of slightly increased concentrations in fatty dairy products and fats/oils, the contribution from dairy products and fats/oils to the total total-TEQ_{2005} intake was higher in 2022 (31 and 23%) than in 2015 (17 and 12%). Both the per capita consumption of meat substitutes and plant-based drinks and the levels of CB 153 and total-TEQ in these food groups were low, and their contributions to the total per capita intakes were very small (<0.2%).

The estimated total per capita intakes were lower in the Market Basket 2022 than in 2015 for both CB 153 (mean 30 vs 55-56 ng/day) and total-TEQ_{2005} (23-31 vs 30-41 pg TEQ/day) (Swedish Food Agency, 2017). Statistical analyses (log-linear regression) of temporal trends including all previous market basket studies (1999, 2005, 2010, 2015) showed that the per-capita intake of CB 153 and total-TEQ_{2005} has decreased significantly with -5.9 and -3.8% per year, respectively during the period 1999 to 2022 (Figure 22). As a sensitivity analysis, the per capita fish consumption in line with previous studies (37 g/day) was used in the calculations of intake in Market Basket 2022. This only changed the time trend for CB 153 marginally to -5.7% per year and did not change the time trend for total-TEQ_{2005} at all. The decreasing trends agrees with data on PCBs and dioxins in mother's milk from Swedish first-time mothers, showing decreasing trends for CB 153 (-6% per year) and total-TEQ_{2005} (-5% per year) during the period 1996 to 2022 (Hedvall Kallerman et al., 2024).

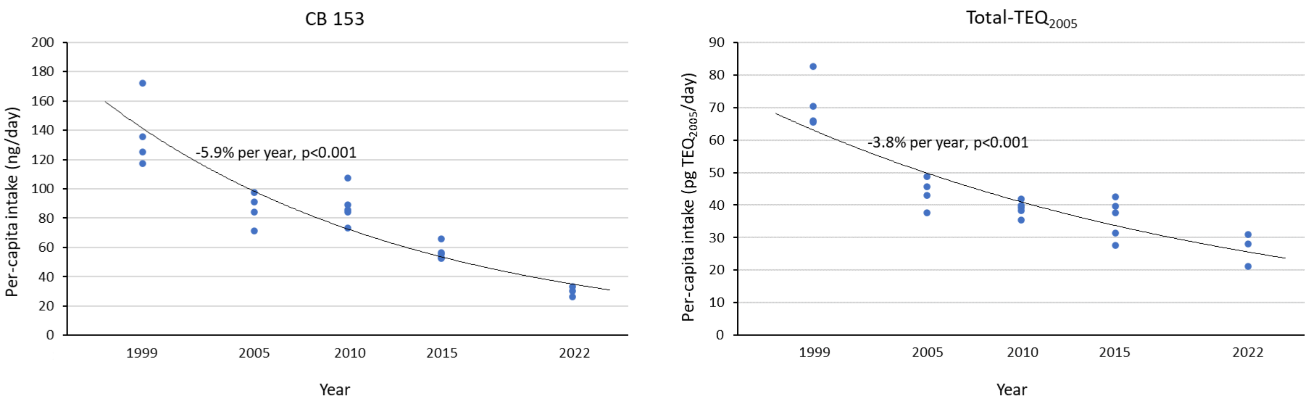

Figure 22. Temporal trends of per capita intake of CB 153 and total-TEQ2005 estimated from market basket studies in Sweden 1999-2022.

Note, that the per capita intake is a function of per capita consumption and concentrations in the food groups. Food groups included are meat, fish, dairy products, eggs and fats/oils. The lines represent regression lines from linear regression analyses with log (ln) transformed per capita intakes. Because of the log transformation, the regression coefficients give the percent change of per capita intake per year. Number of samples per food group was: N=4 (1999 and 2005; four different cities - Gothenburg, Sundsvall, Malmö, Uppsala; mean of two grocery chains per city in 2005), N=5 (2010; five different grocery chains in Uppsala; mean of normal and low price baskets from four of the chains and normal price from the fifth chain), N=5 (2015; five grocery chains in Uppsala) and N=3 (2022; three grocery chains in Uppsala).

8.6.3 Risk assessment

In a risk assessment performed by EFSA in 2005 it was concluded that the toxicological database on ndl-PCBs was too limited to allow for a decision on a tolerable intake (EFSA, 2005b). However, the most sensitive effects in studies with individual ndl-PCB congeners in experimental animals were liver and thyroid toxicity. The NOAELs for these effects in studies with PCB 28, 128, and 153 were in the range of 30-40 µg/kg body weight per day. In addition to EFSA, WHO performed a risk assessment of ndl-PCBs in 2016 and also concluded that available toxicological data did not allow for a group evaluation or derivation of health-based guidance values (World Health Organization, 2016). However, to provide guidance on human health risks, the committee calculated margin of exposures (MOEs) for individual PCB congeners based on minimal effect doses from animal studies (changes in liver and thyroid histopathology). For CB 153, they used a minimal external effect dose of 7 µg/kg body weight per day. Comparing this with the results from the Market Basket 2022 (CB 153 intake 27-33 ng/day or 0.4-0.5 ng/kg body weight/day assuming a body weight of 70 kg) gives a MOE of 14,000 to 17,500.

In 2018, the EFSA panel on contaminants in the food chain established a tolerable weekly intake (TWI) for dl-PCBs and PCDD/Fs (total-TEQ_{2005}) of 2 pg TEQ_{2005}/kg body weight/week (EFSA, 2018a). The TWI was based on effects on semen quality in 9-year-old boys following pre- and postnatal exposure and is protective for the general population and prevents women from reaching a concentration in blood that could cause pre- and postnatal effects. Assuming an average body weight in the Swedish population of 70 kg, the total MB intake of total-TEQ_{2005} based on the Market Basket 2022 (21-31 pg TEQ_{2005}/day, Table 22) corresponds to 2.1-3.1 pg TEQ_{2005}/kg body weight/week. This is at the same level or up to 50% higher than the TWI. Using the TEFs from 2022 and assuming a body weight of 70 kg, the total intake on body weight basis is 1.5-2.7 pg TEQ_{2022}/kg body weight/week. However, it is not possible to compare this intake with the current TWI since the TWI is based on TEFs from 2005 (EFSA, 2018a).

8.6.4 Conclusion

Concentrations of CB 153, dl-PCB TEQ_{2005} and PCDD/F TEQ_{2005} were highest in fatty fish, followed by fats/oils and fatty dairy products. These food groups were also, together with meat, the largest contributors to the total intake of CB 153 and total-TEQ_{2005}. The estimated total per capita intake of CB 153 and total-TEQ_{2005} was lower in the Market Basket 2022 compared with 2015 and the intake decreased with 4-6% per year between 1999 and 2022. These results suggest positive effects of risk management efforts to reduce exposure from food. However, the estimated mean MB per capita intake of total-TEQ_{2005} is at the same level or exceeds the TWI established by EFSA, and a continued decrease in exposure from food is desirable.

8.7 Organochlorine pesticides

Organochlorine pesticides are chemically stable and lipophilic and hence tend to bioaccumulate in animals and biomagnify in aquatic food webs. They have been used worldwide but were banned in most developed countries, including Sweden, already in the 1960s or 1970s. However, because of their stability, high volume production, long time use, and long-range atmospheric transport they are still ubiquitous environmental contaminants found in both wildlife and humans. Examples of organochlorine pesticides are dichlorodiphenyltrichloroethane (DDT), chlordanes, hexachlorocyclohexane (HCH) and hexachlorobenzene (HCB). DDT, chlordanes and HCH have been widely used as insecticides mainly in agriculture and DDT also in malaria control. HCB has been used as a fungicide, but it is also formed unintentionally as a contaminant in chemical and combustion processes. (Bernes, 1998, Ålander et al., 2012).

In the Market Basket 2022, organochlorine pesticides were analysed in seven selected food groups that are known to contribute most to exposure, i.e. meat, lean and fatty fish, lean and fatty dairy products, eggs, and fats/oils. In addition, the compounds were analysed in meat substitutes and plant-based drinks since these food groups were not included in previous market basket studies and levels of organochlorine pesticides in these products on the Swedish market are largely unknown.

The chemical analyses were performed at the Swedish Food Agency using gas chromatography with dual electron capture detectors (GC/ECD). The analytical method is further described in Appendix 4 (section A 4.6). Determined compounds were HCB, HCHs (α-, β-, γ-HCH), chlordanes (α-, γ-chlordane, oxychlordane, trans-nonachlor) and DDT-analogues and their metabolites (o,p'-DDT, p,p'-DDT, p,p'-DDE and p,p'-DDD). LOQ varied depending on the matrix and the quantified analyte, ranging from 4 to 66 ng/kg fresh weight.

8.7.1 Concentrations in food groups

Concentrations of organochlorine pesticides in different food groups in the Market Basket 2022 are presented in Table 23. The levels are generally low, and several substances had concentrations below LOQ in most food groups. The most frequently quantified pesticides were HCB and p,p'-DDE, with the highest mean concentrations found in fatty fish (mean concentrations 0.65 and 2.0 µg/kg, respectively). The HCH and chlordane analogue found in highest concentrations was β-HCH and trans-nonachlor, respectively. α-chlordane, γ-chlordane, o,p'-DDT and p,p'-DDD could only be quantified in fish and α-HCH, oxychlordane, trans-nonachlor could only be quantified in fish and fatty dairy products or eggs. Fatty fish was the only food group that contained quantifiable concentrations of all analysed pesticides. In contrast, lean dairy products and plant-based drinks did not contain quantifiable concentrations of any of the analysed pesticides.

Table 23. Concentrations of organochlorine pesticides (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 samples per food group).

		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
Fat (%)	Mean	12.0	2.0	13.5	9.5	1.1	25.6	2.7	9.3	71.4
	Min	11.4	1.8	12.3	7.9	0.9	25.0	2.4	9.0	70.1
	Median	12.2	1.9	12.8	10.3	1.2	25.7	2.9	9.0	70.4
	Max	12.3	2.3	15.4	10.3	1.2	26.2	2.9	9.8	73.7
HCB (ng/kg)	Mean	64	177	652	0	0	198	0	51	161
	Min	60	170	532	<3.8	<29	193	<29	48	117
	Median	61	172	635	<4.7	<30	200	<29	50	177
	Max	69	189	790	<4.8	<30	201	<29	54	190
α-HCH (ng/kg)	Mean	0	13	53	0	0	6.8	0	0	0
	Min	<4.5	11	47	<3.8	<30	6.5	<29	<7.9	<22
	Median	<4.6	11	51	<4.7	<30	6.5	<29	<8.1	<25
	Max	<4.7	17	60	<4.8	<66	7.5	<29	<10	<25
β-HCH (ng/kg)	Mean	14	75	82	5.6	0	55	0	0	0
	Min	11	23	79	<4.8	<20	14	<19	<7.9	<22
	Median	15	88	80	5.0	<20	75	<20	<8.1	<25
	Max	17	113	88	9.3	<44	76	<20	<10	<25
γ-HCH (ng/kg)	Mean	3.6	11	19	6.5	0	12	0	0	0
	Min	<4.6	9.8	14	4.2	<9.9	8.3	<9.6	<16	<22
	Median	<4.7	11	21	6.7	<9.9	11	<9.8	<16	<25
	Max	6.1	12	22	8.5	<22	16	<9.8	<20	<25
oxychlordane (ng/kg)	Mean	0.0	23	76	0	0	6.5	0	0	0
	Min	<4.5	19	73	<3.8	<9.9	5.3	<9.6	<16	<22
	Median	<4.6	20	77	<4.7	<9.9	6.5	<9.8	<16	<25
	Max	<4.7	29	78	<4.8	<9.9	7.6	<9.8	<20	<25
α-chlordane (ng/kg)	Mean	0	32	308	0	0	0	0	0	0
	Min	<4.5	26	273	<3.8	<9.9	<4.8	<9.6	<7.9	<22
	Median	<4.6	34	293	<4.7	<9.9	<4.9	<9.8	<8.1	<25
	Max	<4.7	35	359	<4.8	<9.9	<5.0	<9.8	<10	<25
γ-chlordane (ng/kg)	Mean	0	0	49	0	0	0	0	0	0
	Min	<4.5	<9.2	40	<3.8	<9.9	<4.8	<9.6	<7.9	<22

		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
	Median	<4.6	<9.5	48	<4.7	<9.9	<4.9	<9.8	<8.1	<25
	Max	<4.7	<9.7	59	<4.8	<9.9	<5.0	<9.8	<10	<25
trans-nonachlor (ng/kg)	Mean	0	59	432	0	0	0	0	25	0
	Min	<4.5	49	392	<3.8	<9.9	<4.8	<9.6	23	<22
	Median	<4.6	62	419	<4.7	<9.9	<4.9	<9.8	25	<25
	Max	<4.7	66	485	<4.8	<9.9	<5.0	<9.8	26	<25
o,p’-DDT (ng/kg)	Mean	0	0	99	0	0	0	0	0	0
	Min	<8.9	<18	88	<7.6	<20	<9.6	<19	<7.9	<43
	Median	<9.3	<19	92	<9.5	<20	<9.8	<20	<8.1	<50
	Max	<9.3	<19	118	<9.7	<20	<10	<20	<10	<50
p,p’-DDT (ng/kg)	Mean	10	18	323	0	0	11	0	7.2	0
	Min	<9.3	<18	282	<7.6	<20	<10	<19	<7.9	<43
	Median	12	22	332	<9.5	<20	12	<20	<10	<50
	Max	15	25	354	<9.7	<44	16	<20	13	<50
p,p’-DDE (ng/kg)	Mean	160	112	2020	5.7	0	380	0	100	158
	Min	71	80	1600	3.9	<19	310	<19	91	93
	Median	106	126	2140	5.3	<20	380	<20	99	161
	Max	304	129	2320	8.0	<20	449	<20	111	221
p,p’-DDD (ng/kg)	Mean	0	18	466	0	0	0	0	0	0
	Min	<8.9	<18	426	<7.6	<20	<9.6	<19	<7.9	<43
	Median	<9.3	22	484	<9.5	<20	<9.8	<20	<8.1	<50
	Max	<9.3	22	487	<9.7	<44	<10	<20	<10	<50

< indicates a value below limit of quantification (LOQ). A hybrid bound approach was used when the means were calculated, i.e. concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero).

8.7.2 Exposure estimations and time trends

Total per capita intake was calculated for HCB, p,p’-DDE, sumDDT (sum of o,p’-DDT, p,p’-DDT, p,p’-DDE and p,p’-DDD) and for the HCH and chlordane present in highest concentrations (i.e. β-HCH and trans-nonachlor). Estimated mean intakes in the Swedish population (per capita intakes) are presented in Table 24 and the contribution of each food group to the total per capita intakes are presented in Figure 23.

The mean total per capita intake was highest for sumDDT, followed by p,p’-DDE and HCB (Table 24). The intakes of β-HCH and trans-nonachlor were more than 10 times lower than the intake of sumDDT and about 5 times lower than the HCB intake. The concentrations of all compounds were below LOQ in almost all samples of meat substitutes, lean dairy products and plant-based drinks, and this resulted in large differences between upper bound and hybrid bound intakes.

Fatty fish was the largest contributor to p,p’-DDE and sumDDE intake (34-41%), followed by meat (26-29%) and fatty dairy products (22-25%) (Figure 23). The estimated intake of HCB was more evenly distributed between fatty fish (23%), meat (24%), and fatty dairy products (27%). Since several food groups had concentrations of β-HCH and trans-nonachlor below LOQ, the estimates for these compounds are more uncertain. However, fatty fish was the predominant contributor to trans-nonachlor intake and fatty dairy products was most important for β-HCH. Lean dairy products, meat substitutes and plant-based drinks did not contribute significantly to the intake of any of the pesticides (<0.5%). The contribution of different food groups to the total HCB and p,p’-DDE intake was similar in the present study as in the Market Basket 2015, with fish, fatty dairy products and meat being the most important food groups (Swedish Food Agency, 2017).

Table 24. Mean daily intake of HCB, p,p'-DDE, sumDDT (sum of o,p'-DDT, p,p'-DDT, p,p'-DDE and p,p'-DDD), β-HCH and trans-nonachlor from different food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita cons g/day		Per capita intake HCB ng/day	p,p'-DDE ng/day	sumDDT ng/day	β-HCH ng/day	trans-nonachlor ng/day
Meat	194	LB			33		0
		HB	12	31	33	2.8	0
		UB			37		0.9
Lean fish	15	LB			2.1		
		HB	2.7	1.7	2.2	1.1	0.9
		UB			2.6		
Fatty fish			12	36	52	1.5	7.8
Meat substitutes	3	LB	0		0.02	0	0
		HB	0	0.02	0.02	0.02	0
		UB	0.01		0.1	0.02	0.01
Lean dairy products	248	LB	0	0	0	0	0
		HB	0	0	0	0	0
		UB	7.4	4.9	24	6.9	2.5
Fatty dairy products	70	LB			27		0
		HB	14	27	27	3.8	0
		UB			29		0.3
Plant-based drinks	13	LB	0	0	0	0	0
		HB	0	0	0	0	0
		UB	0.4	0.3	1.0	0.3	0.1
Eggs	29	LB			3.0	0	
		HB	1.5	2.9	3.1	0	0.7
		UB			3.7	0.3	
Fats and oils	55	LB			8.7	0	0
		HB	8.9	8.7	8.7	0	0
		UB			17	1.3	1.3
Total		**LB**	**51**	**107**	**126**	**9.2**	**9.4**
		HB	**51**	**107**	**127**	**9.2**	**9.4**
		UB	**59**	**112**	**166**	**18**	**15**
ng/kg bw/day		**HB**	**0.7**	**1.5**	**1.8**	**0.13**	**0.13**

LB, lower bound (i.e. 0 is used for <LOQ); HB, hybrid bound (i.e. 0.5*LOQ is used for <LOQ, except for when all three samples in one food group have concentrations below LOQ. In those cases, 0 was imputed for <LOQ); UB, upper bound (i.e. LOQ is used for <LOQ). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

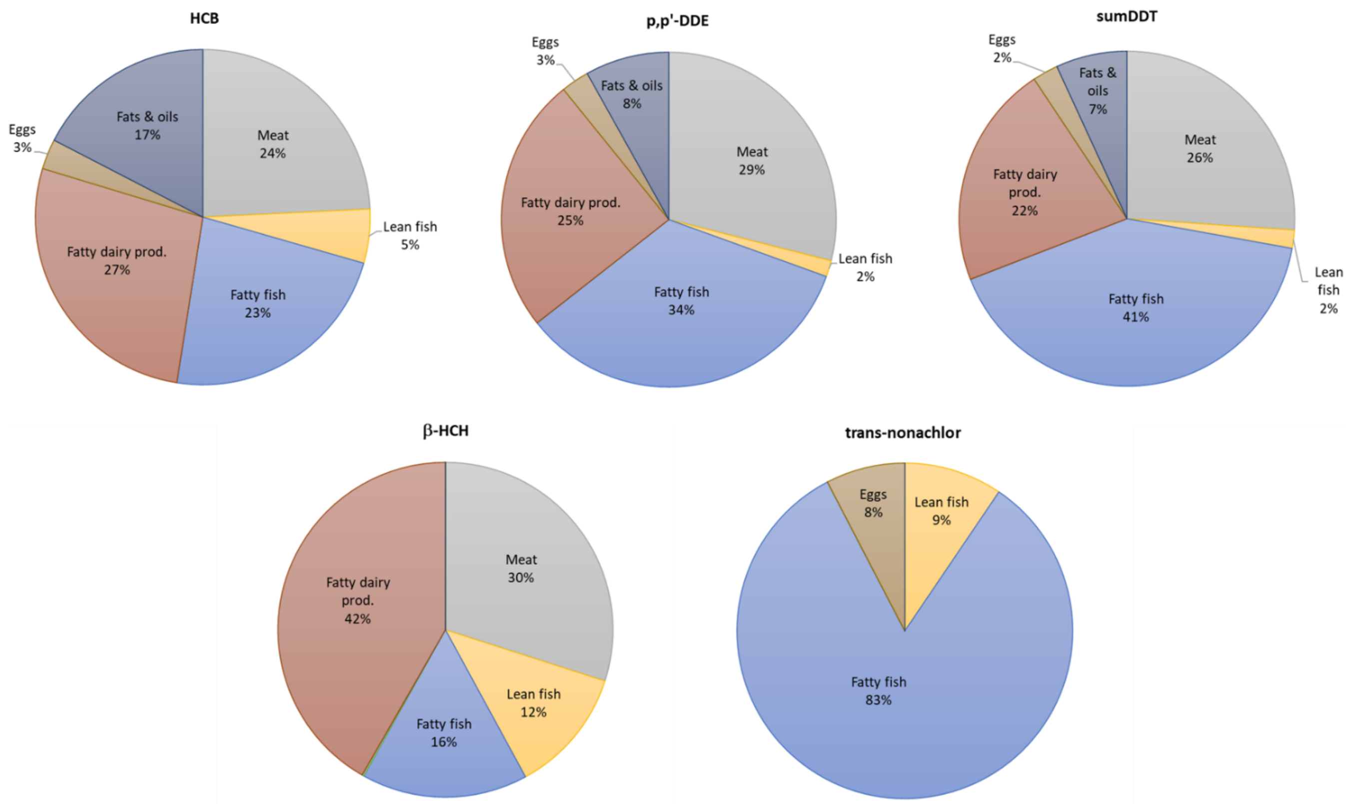

Figure 23. Percentage contribution to the per capita intake of HCB, p,p'-DDE, sumDDT (sum of o,p'-DDT, p,p'-DDT, p,p'-DDE and p,p'-DDD), β-HCH and trans-nonachlor from food groups in the Market Basket 2022.

Food groups contributing with less than 0.5% to the total intake are not included in the pie charts. The percentages are based on mean per capita intake per food group. A hybrid bound (HB) approach was used when calculating means, i.e. 0.5*LOQ was used for concentrations <LOQ, except for when all three samples in one food group had concentrations below LOQ. In those cases, 0 was imputed for <LOQ.

Temporal trends including per-capita intakes from all market basket studies (1999, 2005, 2010, 2015, 2022) were evaluated for HCB, p,p'-DDE, β-HCH and trans-nonachlor (Figure 24). The temporal trend for trans-nonachlor only included intake from fish because that was the only food group that was analysed in the 2010 study.

The estimated total per capita intakes of HCB and p,p'-DDE were lower in the Market Basket 2022 than in 2015 (51 vs 82 ng HCB/day and 107 vs 134 ng p,p'-DDE/day) (Swedish Food Agency, 2017). Statistical analyses (log-linear regression) showed that the total per-capita intake of HCB and p,p'-DDE decreased significantly with -2.8 and -4.3% per year, respectively, during the period 1999 to 2022 (Figure 24). As can be seen in Figure 24, there is one possible outlier for HCB in 2010 (166 ng/day). However, the decrease per year did not change when this outlier was excluded. The intake of trans-nonachlor from fish decreased with 5.7% per year between 1999 to 2022. Decreasing exposure to HCB, p,p'-DDE and trans-nonachlor from food agrees with results from a trend study of mother's milk from Swedish first-time mothers, showing decreasing trends for HCB (-4.6% per year), p,p'-DDE (-6.7% per year) and trans-nonachlor (-6.3% per year) during the period 1996 to 2022 (Hedvall Kallerman et al., 2024). We did not observe any significant trend for β-HCH intake, but the low concentrations of this substance, with many samples with concentrations below LOQ, makes the intake estimations and the trend very uncertain. However, levels of β-HCH in Swedish mother's milk decreased with 10% per year from 1996-2022 (Hedvall Kallerman et al., 2024).

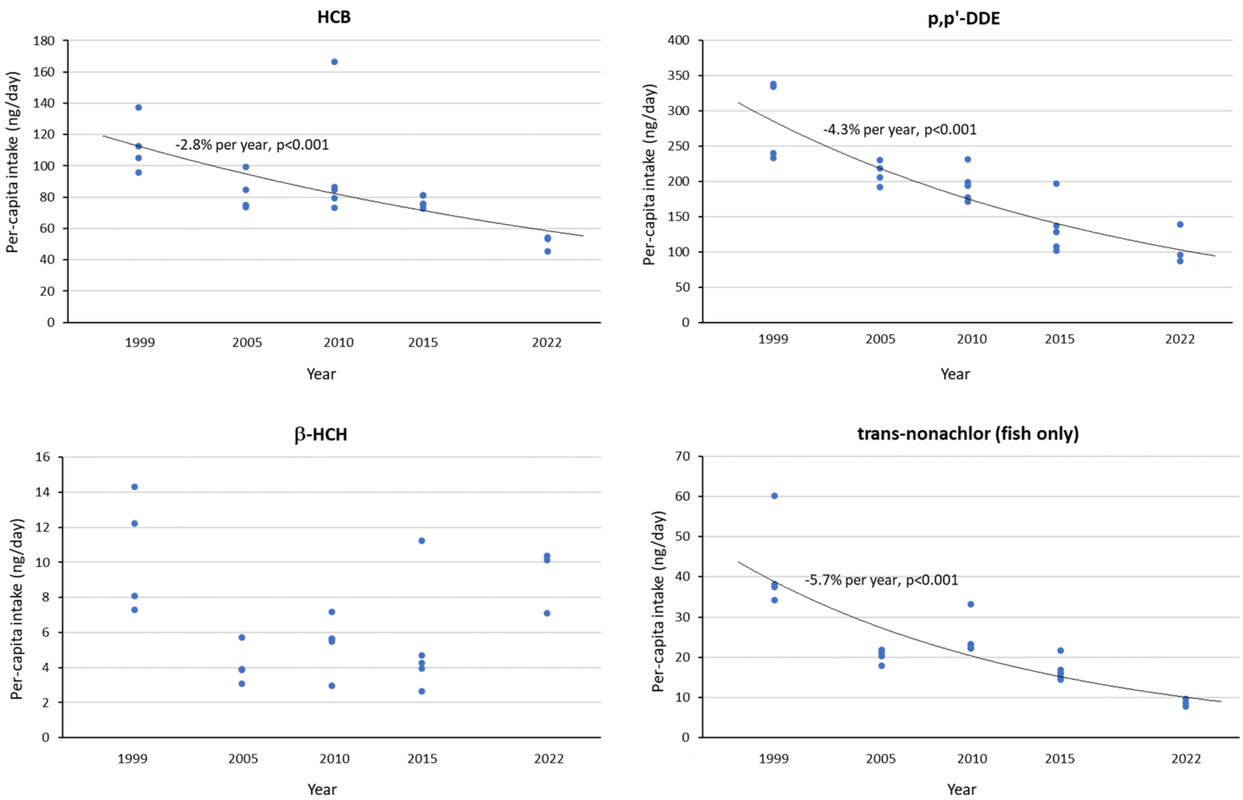

Figure 24. Temporal trends of per capita intake of HCB, p,p'-DDE, β-HCH and trans-nonachlor estimated from market basket studies in Sweden 1999-2022.

Note, that the per capita intake is a function of per capita consumption and concentrations in the food groups. Food groups included are meat, fish, dairy products, eggs and fats/oils. The trend for trans-nonachlor is however based on only fish because this substance was only analysed in fish in 2010. All intakes are calculated using the hybrid bound (HB) approach. The lines represent regression lines from linear regression analyses with log (ln) transformed per capita intakes. Following the log transformation, the regression coefficients give the percent change of per capita intake per year. Number of samples per food group was: N=4 (1999 and 2005; four different cities - Gothenburg, Sundsvall, Malmö, Uppsala; mean of two grocery chains per city in 2005), N=5 (2010 and 2015; five different grocery chains in Uppsala) and N=3 (2022; three grocery chains in Uppsala).

A different data source for fish consumption was used in 2022 compared to previous market basket studies (see section 8.1). As a sensitivity analysis, the per capita fish consumption in line with previous studies (37 g/day instead of 33 g/day) was used in the calculations of intake in the Market Basket 2022. This only changed the time trends for HCB, p,p'-DDE and trans-nonachlor marginally to -2.7, -4.2 and -5.4% per year, respectively.

8.7.3 Risk assessment

Health-based reference values were found for HCB and DDT.

Based on animal studies, the World Health Organization has proposed a health-based guidance value for HCB intake of 170 ng/kg bw/day for non-cancer effects (based primarily on hepatic effects) and 160 ng/kg bw/day for cancer (World Health Organization/IPCS, 1997). The total hybrid bound per capita intake of HCB based on the Market Basket 2022 is 51 ng/day (Table 24). Assuming an average body weight in the Swedish population of 70 kg, this corresponds to 0.7 ng/kg bw/day, which is about 200 times lower than the proposed guidance values.

The Joint FAO/WHO Meeting on Pesticide Residues (JMPR) established a provisional tolerable daily intake for DDT-compounds of 10,000 ng/kg body weight (JMPR, 2001). Using the hybrid bound per capita intake of sumDDT from the Market Basket 2022 (127 ng/day, Table 24) and a body weight of 70 kg, the daily intake can be estimated to 1.8 ng/kg bw/day. This is more than 5000 times lower than the intake considered safe by JMPR.

8.7.4 Conclusion

Of the organochlorine pesticides included in the Market Basket 2022, HCB and p,p'-DDE were found in highest concentrations, and the intake estimations for these substances are consequently more reliable than for the other substances. The highest concentrations were found in fatty fish and fatty dairy products. These food groups were also, together with meat, the largest contributors to the total intake. The estimated total per capita intake of HCB and p,p'-DDE was lower in the Market Basket 2022 compared with 2015 and the intake decreased with 3-4% per year between 1999 and 2022. Although more uncertain, the intake of trans-nonachlor also decreased between 1999 and 2022, while no time trend was observed for β-HCH. Estimated per capita intakes of both HCB and p,p'-DDE were well below health-based reference values and is with current knowledge not of health concern for the general Swedish population.

8.8 Brominated flame retardants (BFRs)

Brominated flame retardants (BFRs), for example polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCDD), have been used worldwide since the 1970s. PBDEs have been added to a large variety of consumer products such as furniture upholstery, textiles, plastics and electronic products, while a main application of HBCDD has been in polystyrene foam that is used in building construction. PBDEs and HBCDD are additive flame retardants, simply blended with the polymers, and therefore prone to leach out of the products. (Alaee et al., 2003, EFSA, 2024b, EFSA, 2021)

Production and use of commercial formulations of penta-, octa- and deca-BDEs have been strictly regulated in Europe since 2004 and 2008, respectively, and most other regions of the world adopted similar restrictions in the following years (Abbasi et al., 2019, EFSA, 2024b). Further, both PBDEs and HBCDD have been listed on Annex A (chemicals to be eliminated) of the Stockholm Convention (EFSA, 2021, EFSA, 2024b). The restrictions have led to a global phase-out of commercial production and use of PBDEs and HBCDD. However, there are still many products in use that contain these chemicals, and they will probably continue to leach out from products during use, disposal and recycling processes for many years.

In the Market Basket 2022, brominated flame retardants were analysed in seven selected food groups that are known to contribute most to exposure, i.e. meat, lean and fatty fish, lean and fatty dairy products, eggs, and fats/oils. In addition, the compounds were analysed in meat substitutes and plant-based drinks since these food groups were not included in previous market baskets and levels of brominated flame retardants in these products on the Swedish market are mainly unknown.

The chemical analyses were performed at the Swedish Food Agency using gas chromatography/mass spectrometry in negative ion chemical ionization mode (GC/MS NCI). The analytical method is further described in Appendix 4 (section A 4.7). Determined compounds included nine PBDE congeners (BDE-28, -47, -66, -99, -100, -153, -154, -183, -209) and HBCDD. The LOQ varied between 0.4 and 46 ng/kg fresh weight, depending on the analyte. Highest LOQ was determined for BDE-209, due to its complexity.

8.8.1 Concentrations in food groups

Concentrations of brominated flame retardants in the food groups analysed are presented in Table 25. The levels were generally low, mostly below LOQ. Overall, PBDEs were found most frequently and in highest concentrations in fatty fish, followed by meat, lean fish and fats/oils. In contrast, only one analytical result above LOQ was obtained for meat substitutes, lean dairy products and plant-based drinks, respectively. BDE-99, BDE-153, BDE-154 and HBCDD were quantified in the largest number of food groups and samples, and the highest concentrations were found for BDE-47 and HBCDD in fatty fish (100 and 74 ng/kg, respectively) and BDE-209 in fats and oils (50 ng/kg). It should be noted that the LOQs for BDE-209 were considerably higher than for the other PBDEs.

Table 25. Concentrations of brominated flame retardants (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 samples per food group).

		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
Fat (%)	Mean	12.0	2.0	13.5	9.5	1.3	25.6	2.9	9.3	72.2
	Min	11.4	1.8	12.3	7.9	1.3	25.0	2.4	9.0	71.6
	Median	12.2	1.9	12.8	10.3	1.3	25.7	3.1	9.0	72.3
	Max	12.3	2.3	15.4	10.3	1.3	26.2	3.1	9.8	72.7
BDE-28	Mean	0	0	7.5	0	0	0	0	0	0
(ng/kg)	Min	<0.45	<0.92	5.8	<0.38	<1.2	<0.48	<1.2	<0.79	<1.1
	Median	<0.46	<0.95	6.8	<0.47	<1.2	<0.49	<1.2	<0.81	<1.2
	Max	<0.47	<0.97	9.9	<0.48	<1.2	<0.50	<1.2	<1.0	<1.2
BDE-47	Mean	2.5	6.4	100	0	0	0	0	0	0
(ng/kg)	Min	<2.9	<6.1	78	<2.5	<9.4	<3.2	<9.6	<3.1	<7.5
	Median	<3.1	7.3	106	<3.1	<9.7	<3.2	<9.7	<3.3	<7.7
	Max	4.6	8.8	117	<3.2	<9.8	<3.3	<9.7	<4.0	<7.7
BDE-66	Mean	0	0.84	32	0	0	0	0	0	6.2
(ng/kg)	Min	<0.45	<0.97	22	<0.38	<1.2	<0.48	<1.2	<0.79	<1.1
	Median	<0.46	1.0	35	<0.47	<1.2	<0.49	<1.2	<0.81	<1.2
	Max	<0.47	1.0	37	<0.48	<1.2	<0.50	<1.2	<1.0	17
BDE-99	Mean	3.5	3.5	17	1.0	0	1.8	0	0	4.6
(ng/kg)	Min	2.6	<3.0	13	<1.6	<6.9	<1.6	<7.1	<6.3	<3.8
	Median	3.7	<3.2	18	<1.6	<7.1	1.9	<7.1	<6.5	5.4
	Max	4.0	7.5	22	1.5	<7.2	2.8	<7.1	<8.0	6.4
BDE-100	Mean	0.62	1.6	24	0	0	0.37	0	0	0
(ng/kg)	Min	<0.45	<0.92	17	<0.38	<1.4	<0.49	<1.5	<3.1	<1.1
	Median	0.63	1.9	24	<0.47	<1.5	<0.50	<1.5	<3.3	<1.2
	Max	1.0	2.3	32	<0.48	<1.5	0.62	<1.5	<4.0	<1.2
BDE-153	Mean	0.77	0.66	6.3	0	0	0.66	0	0.75	2.1
(ng/kg)	Min	0.67	<0.92	4.7	<0.38	<3.6	0.51	<3.7	<1.0	2.1
	Median	0.74	<0.97	6.4	<0.47	<3.8	0.70	<3.8	0.86	2.1
	Max	0.90	1.0	7.8	<0.48	<3.8	0.77	<3.8	0.89	2.2
BDE-154	Mean	0.63	1.6	18	0	0	0	0	1.9	1.0
(ng/kg)	Min	0.58	1.1	12	<0.38	<1.2	<0.48	<1.2	1.5	<1.1

		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
	Median	0.65	1.8	16	<0.47	<1.2	<0.49	<1.2	2.1	<1.2
	Max	0.67	2.0	26	<0.48	<1.2	<0.50	<1.2	2.2	2.0
BDE-183 (ng/kg)	Mean	0.31	0	0	0	0	0	0	0	0
	Min	<0.46	<0.92	<0.92	<0.38	<1.2	<0.48	<1.2	<0.79	<1.1
	Median	<0.47	<0.95	<0.97	<0.47	<1.2	<0.49	<1.2	<0.81	<1.2
	Max	0.45	<0.97	<0.98	<0.48	<1.5	<0.50	<1.2	<1.0	<1.2
BDE-209 (ng/kg)	Mean	18	0	0	0	3.0	0	3.8	0	50
	Min	<18	<37	<37	<15	<4.1	<19	<4.0	<7.9	<46
	Median	<19	<38	<39	<19	<4.1	<20	<4.1	<8.1	47
	Max	36	<39	<39	<19	5.0	<20	7.5	<10	80
HBCDD (ng/kg)	Mean	2.2	0	74	1.1	0	1.6	0	2.5	10
	Min	1.5	<1.8	53	<0.97	<2.4	1.6	<2.5	<1.6	2.6
	Median	1.7	<1.9	74	1.0	<2.5	1.6	<2.5	2.3	12
	Max	3.3	<1.9	95	1.8	<2.5	1.6	<2.5	4.5	16

< indicates a value below limit of quantification (LOQ). A hybrid bound approach was used when the means were calculated, i.e. concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero).

8.8.2 Exposure estimations and time trends

Estimated mean per capita intakes of PBDEs and HBCDD in the Swedish population and the contribution of each food group to the total intakes are presented in Table 26 and Figure 25. BDE-183 is excluded because there were only one sample (meat) with a quantifiable concentration.

BDE-209, followed by HBCDD, BDE-47 and BDE-99 showed the highest intakes, mean HB values varying between 1.4 and 7.1 ng/day (Table 26). The intakes of BDE-66, BDE-100, BDE-153 and BDE-154 were around 0.5-0.9 ng/day, and the lowest estimated intake was 0.14 ng/day for BDE-28. The large number of samples with concentrations below LOQ resulted in large differences between the LB and UB intake estimations for most compounds.

Even if there were compound-specific differences, the overall main contributors to the intake of brominated flame retardants were fatty fish, meat and fats/oils (Figure 25). Fatty fish was the largest contributor to BDE-47, BDE-66, BDE-100, BDE-154 and HBCDD intake (53-75%), while meat was the dominating food group for BDE-99 and BDE-209 (47-50%). The distribution between food groups was more even for BDE-153, but meat showed a slightly higher contribution (33%) to the total intake than fats/oils (26%) and fatty fish (25%). BDE-28 could only be quantified in fatty fish, and fatty fish consequently contributed to 100% of the intake if applying the hybrid bound approach (results not shown). Lean fish, fatty and lean dairy products and eggs contributed with a few percent to the intake of some of the compounds, while the intake from plant-based drinks and meat substitutes was insignificant.

The estimated HB total per capita intakes of BDE-28, BDE-47, BDE-100, BDE-153, BDE-154 and HBCDD in the Market Basket 2022 were slightly lower than the median intakes estimated in the Market Basket 2015 (Swedish Food Agency, 2017). Intakes of BDE-66 and BDE-99 were approximately similar, while the intake of BDE-209 was higher in 2022 (7.1 ng/day) than in 2015 (3.4 ng/day). Statistical analyses (log-linear regression) showed that the total per capita intake of BDE-47, BDE-99, BDE-100, BDE-153 and BDE-154 decreased significantly with 2.4 to 9.4% per year during the period 1999 to 2022 (Figure 26). BDE-28, BDE-66 and HBCDD were not analysed in 1999, but the intake of BDE-28 and HBCDD decreased between 2005 and 2022 while there was no trend for the BDE-66 intake (Figure 26). There reason for the lack of trend for BDE-66 is unknown, but it can be noticed that the variation in intake between samples is large.

BDE-209 was only analysed in the market baskets in 2010, 2015 and 2022. It seemed like the intake of BDE-209 decreased between 2010 and 2015 (Swedish Food Agency, 2017), but there is no significant trend after adding the data for 2022 (Figure 26). The results from different years are however difficult to compare due to high and varying LOQs, making the trend for BDE-209 uncertain.

A different data source for fish consumption was used in 2022 compared to previous market basket studies (see section 8.1). As a sensitivity analysis, the per capita fish consumption in line with previous studies (37 g/day instead of 33 g/day) was used in the intake calculations of the BFRs with a time trend in the Market Basket 2022. This only changed the time trends marginally (the percent decrease per year became 0.1-0.5 units lower).

The observed decreasing trends show that measures to reduce production and use of PBDEs and HBCDD have resulted in reduced contamination of foods on the market. The temporal trends observed in the market basket studies also agree with a trend study of brominated flame retardants in Swedish mother's milk, showing decreasing levels of BDE-47, BDE-99, BDE-100 and HBCDD between 1996 and 2022 (5-11% per year) (Hedvall Kallerman et al., 2024). In contrast to market basket data, a decreasing trend of BDE-209 was observed in mother's milk between 2009 and 2022 (-5% per year). However, as already mentioned, the market basket trend for BDE-209 is uncertain.

Table 26. Mean daily intake of PBDEs and HBCDD from different food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Pc cons (g/day)		Per capita intake (ng/day)								
			BDE-28	BDE-47	BDE-66	BDE-99	BDE-100	BDE-153	BDE-154	BDE-209	HBCDD
Meat	194	LB	0	0.30	0		0.10			2.3	
		HB	0	0.49	0	0.67	0.12	0.15	0.12	3.5	0.42
		UB	0.09	0.68	0.09		0.13			4.7	
Lean fish	15	LB	0	0.08	0.01	0.04	0.02	0.005		0	0
		HB	0	0.10	0.01	0.05	0.02	0.01	0.02	0	0
		UB	0.01	0.11	0.01	0.07	0.03	0.01		0.57	0.03
Fatty fish	18	LB								0	
		HB	0.14	1.8	0.57	0.31	0.43	0.11	0.32	0	1.3
		UB								0.69	
Meat substitutes	3	LB	0	0	0	0.002	0	0	0	0	0.003
		HB	0	0	0	0.003	0	0	0	0	0.003
		UB	0.001	0.009	0.001	0.005	0.001	0.001	0.001	0.05	0.004
Lean dairy products	248	LB	0	0	0	0	0	0	0	0.41	0
		HB	0	0	0	0	0	0	0	0.75	0
		UB	0.30	2.4	0.30	1.8	0.36	0.93	0.30	1.1	0.61
Fatty dairy products	70	LB	0	0	0	0.11	0.01		0	0	
		HB	0	0	0	0.13	0.03	0.05	0	0	0.11
		UB	0.03	0.23	0.03	0.15	0.04		0.03	1.4	
Plant-based drinks	13	LB	0	0	0	0	0	0	0	0.03	0
		HB	0	0	0	0	0	0	0	0.05	0
		UB	0.02	0.13	0.02	0.09	0.02	0.05	0.02	0.07	0.03
Eggs	29	LB	0	0	0	0	0	0.02		0	0.07
		HB	0	0	0	0	0	0.02	0.06	0	0.07
		UB	0.03	0.10	0.03	0.20	0.10	0.03		0.25	0.08
Fats and oils	55	LB	0	0	0.32	0.22	0		0.04	2.3	
		HB	0	0	0.34	0.25	0	0.12	0.06	2.8	0.56
		UB	0.06	0.42	0.36	0.29	0.06		0.08	3.2	
Total		**LB**	**0.14**	**2.2**	**0.90**	**1.3**	**0.57**	**0.45**	**0.56**	**5.1**	**2.5**
		HB	**0.14**	**2.4**	**0.92**	**1.4**	**0.60**	**0.46**	**0.58**	**7.1**	**2.5**
		UB	**0.68**	**5.9**	**1.4**	**3.5**	**1.2**	**1.4**	**0.95**	**12**	**3.2**
ng/kg bw/day		**HB**	**0.002**	**0.034**	**0.013**	**0.020**	**0.009**	**0.007**	**0.008**	**0.101**	**0.036**

Pc conc, per capita consumption; LB, lower bound (i.e. 0 is used for <LOQ); HB, hybrid bound (i.e. 0.5*LOQ is used for <LOQ, except for when all three samples in one food group have concentrations below LOQ. In those cases, 0 was imputed for <LOQ); UB, upper bound (i.e. LOQ is used for <LOQ). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

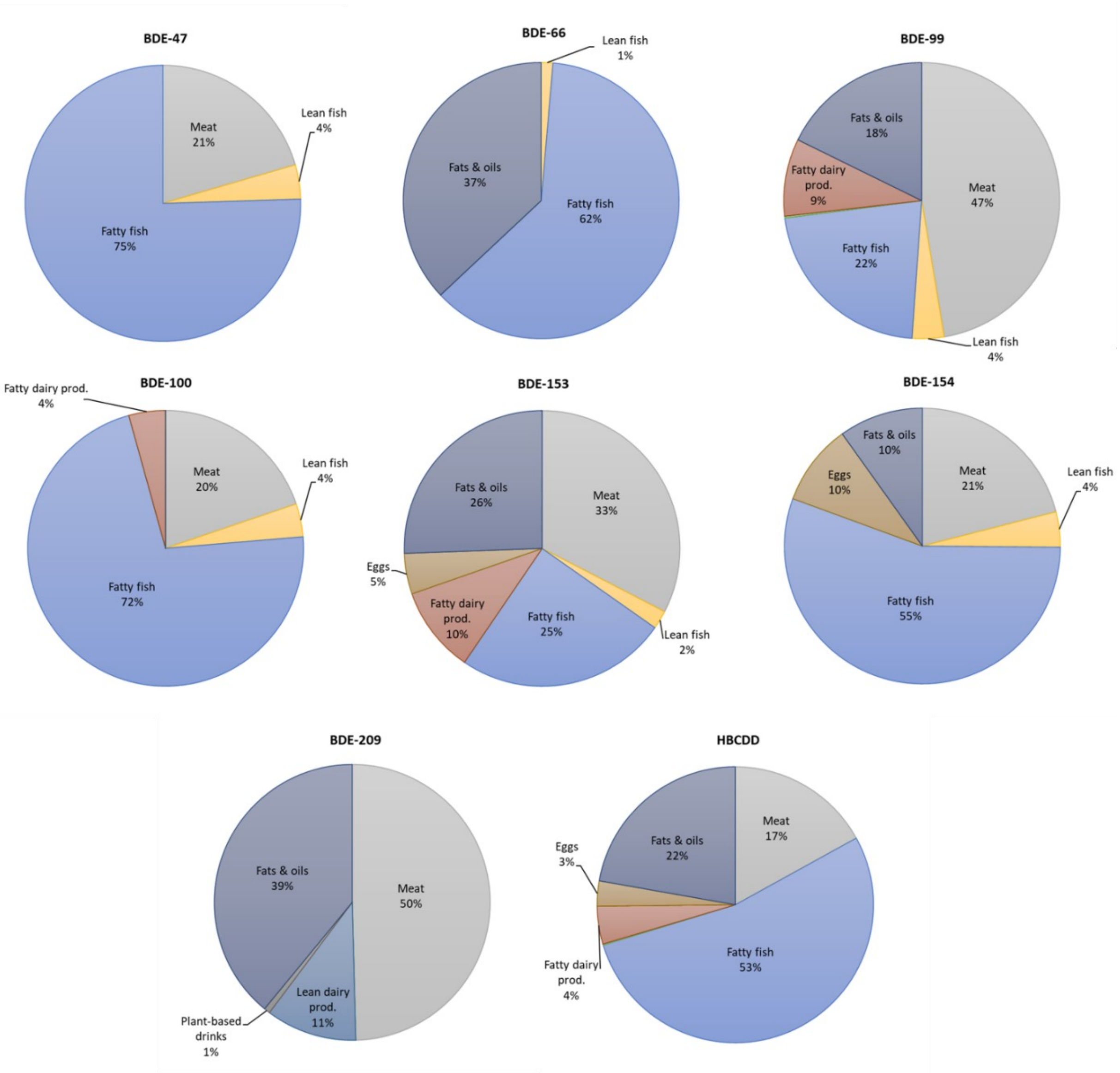

Figure 25. Percentage contribution to the per capita intake of BDE-47, -66, -99, -100, -153, -154, -209 and HBCDD from food groups in the Market Basket 2022.

Food groups contributing with less than 0.5% to the total intake are not included in the pie charts. The percentages are based on mean per capita intake per food group. A hybrid bound (HB) approach was used when calculating means, i.e. 0.5*LOQ was used for concentrations <LOQ, except for when all three samples of one food group had concentrations below LOQ. In those cases, 0 was imputed for <LOQ.

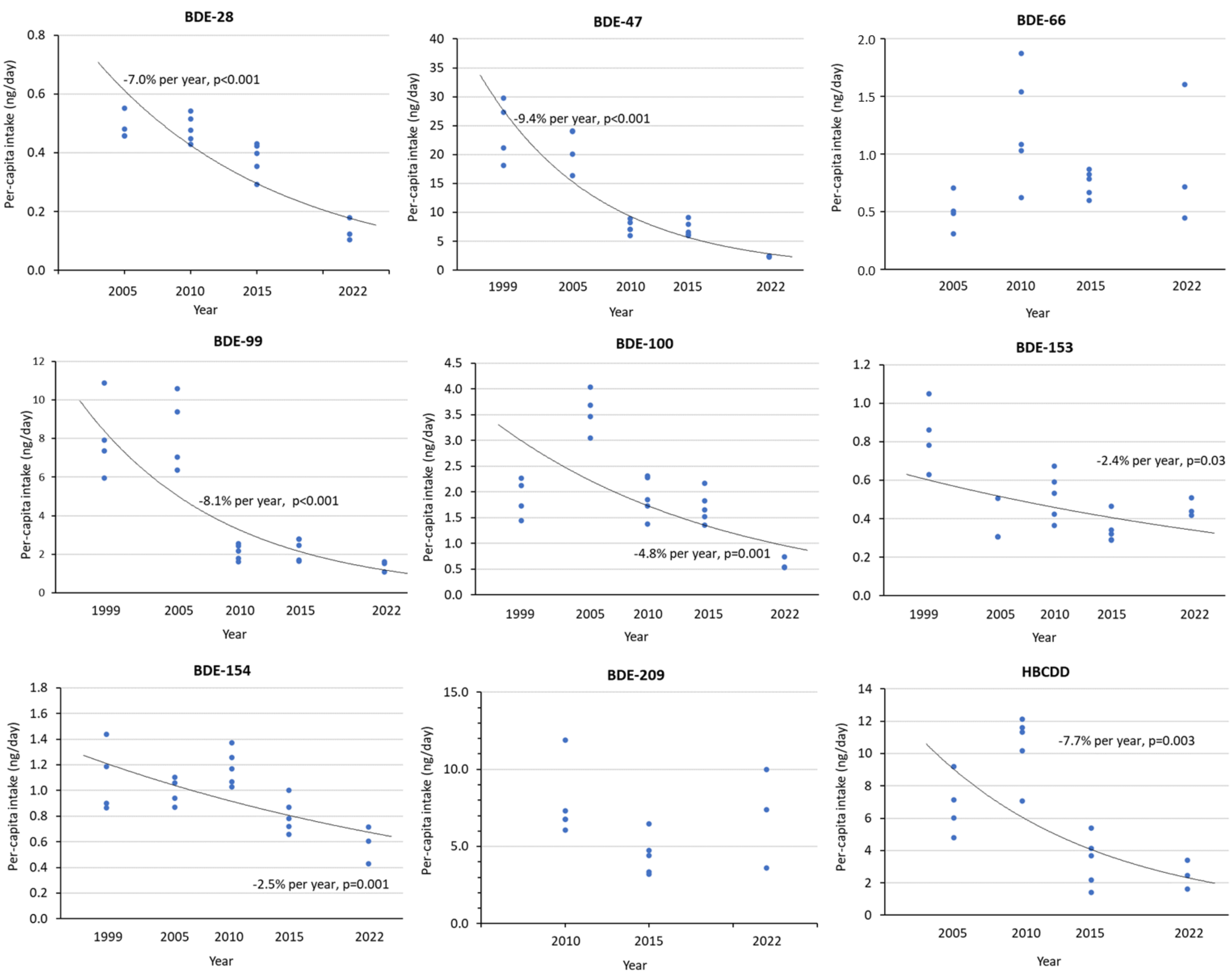

Figure 26. Temporal trends of per capita intake of brominated flame retardants from market basket studies in Sweden.

Note, that the per capita intake is a function of per capita consumption and concentrations in the food groups. Food groups included are meat, fish, dairy products, eggs and fats/oils. All intakes are calculated using the hybrid bound (HB) approach. The lines represent regression lines from linear regression analyses with log (ln) transformed per capita intakes. Because of the log transformation, the regression coefficients give the percent change of per capita intake per year. Number of samples per food group was: N=4 (1999 and 2005; four different cities - Gothenburg, Sundsvall, Malmö, Uppsala; mean of two grocery chains per city in 2005), N=5 (2010; five different grocery chains in Uppsala; mean of normal and low price baskets from four of the chains and normal price from the fifth chain), N=5 (2015; five grocery chains in Uppsala), N=3 (2022; three grocery chains in Uppsala).

8.8.3 Risk assessment

In 2024, the EFSA panel on contaminants in the food chain (CONTAM) updated its risk assessment of PBDEs in food from 2011 (EFSA, 2024b). The panel concluded that neurodevelopmental effects on behaviour and reproductive effects (in rodents) were critical endpoints. For BDE-47, -99, -153 and -209, data was sufficient to derive reference points, i.e. benchmark doses and corresponding lower 95% confidence limits of the benchmark doses (BMDLs) for endpoint-specific benchmark responses. The panel estimated body burdens at the BMDLs in rodents, and then the chronic intakes that would lead to the same body burdens in humans. The lowest BMDLs were derived for neurodevelopmental (BDE-153) and reproductive (BDE-47, -99, -209) effects. Margin of exposure (MOE) for BDE-47, -99, -153 and -209 was estimated by calculating the ratio between the lowest BMDL chronic intake estimated by EFSA and the total per capita intake estimated in the Market Basket 2022 (HB and UB intake) (Table 27). All MOEs were above 100, i.e. the ratio below which the exposure is generally considered to be of health concern. The lowest MOE was found for BDE-153 (160-180), and the highest for BDE-209 (18,000-30,000). However, EFSA also concluded that there is scientific support for including all PBDE congeners in a common assessment group and that it is most appropriate to calculate a combined (total) margin of exposure (MOET) (EFSA, 2024b). A MOET was therefore calculated based on both the HB and UB per capita intake (Table 27). EFSA considered that a MOET for PBDE-exposure smaller than 25 would raise health concern. The estimated MOET based on the Market Basket 2022 is considerably higher (120-350) (Table 27), indicating that the total per capita intake of PBDEs is not a health concern for the general Swedish population.

In an update of the EFSA risk assessment of HBCDD in 2021, the panel on contaminants in the food chain (CONTAM) concluded that neurodevelopmental effects on behaviour in mice can be considered the critical effects (EFSA, 2021). A lowest observed adverse effect level (LOAEL) of 0.9 mg/kg bw was identified as the reference point, corresponding to a body burden of 0.75 mg/kg bw. EFSA estimated the chronic intake that would lead to the same body burden in humans to 2.35 µg/kg bw/day and also concluded that a MOE higher than 24 would indicate a low health concern. MOEs based the estimated HB and UB intakes in the Market Basket 2022 are very high (51,000-65,000) (Table 27) and indicate that current dietary exposure to HBCDDs in Sweden does not raise a health concern.

Table 27. Margin of exposure (MOE) between the reference points for human intakes of PBDEs and HBCDD estimated by EFSA (EFSA, 2021, EFSA, 2024b) and the hybrid bound (HB) and upper bound (UB) per capita intakes estimated in the Market Basket 2022. For PBDEs, a combined (total) margin of exposure (MOET) is also calculated.

Compound	Per capita intake[1] (ng/kg bw/day) HB/UB	Reference point (ng/kg bw/day)	MOE[4] HB/UB	MOET[5] HB/UB
BDE-47	0.034/0.084	168[2]	4900/2000	350/120
BDE-99	0.020/0.050	38.4[2]	1900/770	
BDE-153	0.0066/0.020	3.2[2]	480/160	
BDE-209	0.101/0.171	3000[2]	30,000/18,000	
HBCDD	0.036/0.046	2350[3]	65,000/51,000	

[1] Total per capita intake (HB/UB) based on the Market Basket 2022 (Table 26) and assuming a body weight of 70 kg.

[2] The chronic human dietary intake corresponding to the body burden at the lowest BMDL, estimated by EFSA (EFSA, 2021, EFSA, 2024b).

[3] The chronic human dietary intake corresponding to the body burden at the LOAEL, estimated by EFSA (EFSA, 2021).

[4] Margin of exposure, i.e. the reference point divided by the HB and UB per capita intake, respectively.

[5] Combined (total) margin of exposure. Calculated as the reciprocal of the harmonic sum of the individual substances' MOEs, i.e. 1/(1/MOEBDE-47 + 1/MOEBDE-99 + 1/MOEBDE-153 + 1/MOEBDE-209).

8.8.4 Conclusion

The concentrations of the brominated flame retardants included in the Market Basket 2022 were generally low. The highest concentrations were found for BDE-47 and HBCDD in fatty fish. The overall main contributors to the intake of PBDEs and HBCDD were fatty fish, meat and fats/oils. The estimated intake of BDE-28, -47, -99, -100, -153, -154 and HBCDD decreased with 2-9% per year between 1999 or 2005 and 2022. The margins between estimated dietary exposure to PBDEs and HBCDD and health-based reference points indicate that current dietary exposure is not of health concern for the Swedish general population.

8.9 Per- and polyfluoroalkyl substances (PFAS)

Per- and polyfluoroalkyl substances (PFAS) are a large group of chemicals including thousands of different compounds (OECD, 2021). The area of use spans over a wide variety of fields, such as in textiles and kitchenware due to their water- and grease repellent properties, as well as in fire-fighting foam, industrial applications, and medical equipment. PFAS are considered environmentally persistent or degradable to persistent end products. The major routes of human exposure to PFAS are via food and drinking water (EFSA, 2020a).

In total, 14 different PFAS (see Table 28) have been analysed in the 17 major food groups included in the Market Basket 2022 (Table 1). The chemical analyses were performed at the School of Science and Technology, Örebro University, using liquid chromatography - tandem mass spectrometry (LC-MS/MS). The chemical analyses are further described in appendix A 4.8, and LOQs of different PFAS in the respective matrices are listed in Table 28.

Table 28. Analysed PFAS and limits of quantification (LOQs) (ng/kg wet weight or ng/L) in the Market Basket 2022.

Target	Liquids	Others
PFHxA	<0.2	<20
PFHpA	<0.2	<20
PFOA	<0.2	<20
PFNA	<0.2	<20
PFDA	<0.2	<20
PFUnDA	<0.2	<20
PFDoDA	<0.2	<20
PFTrDA	<0.4	<20
PFTeDA	<0.4	<20
PFBS	<0.2	<20
PFHxS	<0.2	<20
PFOS	<0.2	<20
PFDS	<0.2	<20
FOSA	<0.4	<50

8.9.1 Concentrations in food groups

Several PFAS were detected in lean and fatty fish and eggs (see Table 29). Additionally, PFOA was detected in coffee and tea (0.45-1.1 ng/L), which was likely due to the levels of PFOA found in the drinking water used for brewing (0.45 ng/L in cold water, 0.85 ng/L in brewed water). In the remaining 13 food groups, all levels of PFAS were below the respective LOQs. In lean fish, nine different PFAS were detected (see Table 29), with mean levels ranging between 21 to 225 ng/kg, with the highest levels found for PFUnDA (225 ng/kg) and PFOS (218 ng/kg). The mean sum level of PFAS-4 (sum of PFOA, PFNA, PFHxS and PFOS) in lean fish was 304 ng/kg, and the sum level of all detected PFAS (∑PFAS) were 808 ng/kg. In fatty fish and eggs, only PFOS was detected, with the mean values of 82 and 51 ng/kg, respectively.

Table 29. Concentrations of PFAS in the food groups with detectable levels in the Market Basket 2022 (N=3 samples per food group).

		Lean fish	Fatty fish	Eggs
PFOA (ng/kg)	Mean	21	0	0
	Min	<20	<20	<20
	Median	26	<20	<20
	Max	26	<20	<20
PFNA (ng/kg)	Mean	65	0	0
	Min	53	<20	<20
	Median	63	<20	<20
	Max	78	<20	<20
PFDA (ng/kg)	Mean	51	0	0
	Min	36	<20	<20
	Median	54	<20	<20
	Max	61	<20	<20
PFUnDA (ng/kg)	Mean	225	0	0
	Min	219	<20	<20
	Median	224	<20	<20
	Max	232	<20	<20
PFDoDA (ng/kg)	Mean	51	0	0
	Min	47	<20	<20
	Median	50	<20	<20
	Max	56	<20	<20
PFTrDA (ng/kg)	Mean	111	0	0
	Min	62	<20	<20
	Median	107	<20	<20
	Max	164	<20	<20
PFTeDA (ng/kg)	Mean	36	0	0
	Min	24	<20	<20
	Median	34	<20	<20
	Max	49	<20	<20
PFOS (ng/kg)	Mean	218	82	51
	Min	182	63	48
	Median	205	80	48
	Max	268	103	56
PFOSA (ng/kg)	Mean	31	0	0
	Min	<50	<50	<50
	Median	28	<50	<50
	Max	40	<50	<50
PFAS-4[1] (ng/kg)	Mean	304	82	51
	Min	245	63	48
	Median	294	80	48
	Max	372	103	56
∑PFAS[2] (ng/kg)	Mean	808	82	51
	Min	719	63	48
	Median	848	80	48
	Max	857	103	56

Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was used for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, a lower bound of 0 was used for non-detects when calculating the mean.

[1] Sum of PFOA, PFNA, PFHxS (all levels <LOQ) and PFOS.

[2] Sum of all nine detected PFAS.

8.9.2 Exposure estimations and time trends

The estimated mean daily per capita intake of the different PFAS ranged between 0.32 and 6.3 ng/person/day (see Table 30), with the highest intake of PFOS (6.3 ng/person/day), followed by PFUnDA (3.4 ng/person/day). The estimated mean intake of PFAS-4 was 7.6 ng/person/day (corresponding to 0.11 ng/kg bw/day) and of ∑PFAS was 15 ng/person/day (corresponding to 0.22 ng/kg bw/day).

When considering the contribution from different PFAS to the total intake of ∑PFAS, PFOS contributed the most (41%), followed by PFUnDA (22%) and PFTrDA (11%) (see Figure 27). PFAS-4 contributed with 49% of the total intake of ∑PFAS.

The proportional contribution from the three food groups to the per capita intake of PFOS are presented in Figure 28. Lean fish contributed the most (53%), and the remaining part was evenly divided between eggs (24%) and fatty fish (23%).

Table 30. Mean daily per capita intake of PFAS (ng/person/day) from the food groups with detectable levels and total intake in the Market Basket 2022 (N=3 samples per food group). The total intake from all food groups, are also presented in ng/kg bodyweight/day in addition to the per capita intake.

Food group	Per capita consumption (g/day)		PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFOS	PFOSA	PFAS-4	∑PFAS
Lean fish	15	LB	0.27								0.35	4.6	12
		HB	0.32	0.99	0.78	3.4	0.78	1.7	0.55	3.3	0.48	4.7	12
		UB	0.37								0.61	4.7	13
Fatty fish	18	LB	0	0	0	0	0	0	0		0	1.4	1.4
		HB	0	0	0	0	0	0	0	1.4	0	1.4	1.4
		UB	0.35	0.35	0.35	0.35	0.35	0.35	0.35		0.44	2.1	4.3
Eggs	29	LB	0	0	0	0	0	0	0		0	1.5	1.5
		HB	0	0	0	0	0	0	0	1.5	0	1.5	1.5
		UB	0.58	0.58	0.58	0.58	0.58	0.58	0.58		0.73	2.6	6.3
Total		**LB**	**0.27**	**1.0**	**0.78**	**3.4**	**0.78**	**1.7**	**0.55**		**0.35**	**7.5**	**15**
		HB	**0.32**	**1.0**	**0.78**	**3.4**	**0.78**	**1.7**	**0.55**	**6.3**	**0.48**	**7.5**	**15**
		UB	**1.3**	**1.9**	**1.7**	**4.4**	**1.7**	**2.6**	**1.5**		**1.8**	**9.5**	**23**
ng/kg bw/day		**HB**	**0.005**	**0.01**	**0.01**	**0.05**	**0.01**	**0.02**	**0.008**	**0.09**	**0.007**	**0.11**	**0.22**

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, a lower bound of 0 was used for non-detects; UB, upper bound (i.e. LOQ is used for non-detects). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

[1] Sum of PFOA, PFNA, PFHxS (all levels <LOQ) and PFOS.

[2] Sum of all nine detected PFAS.

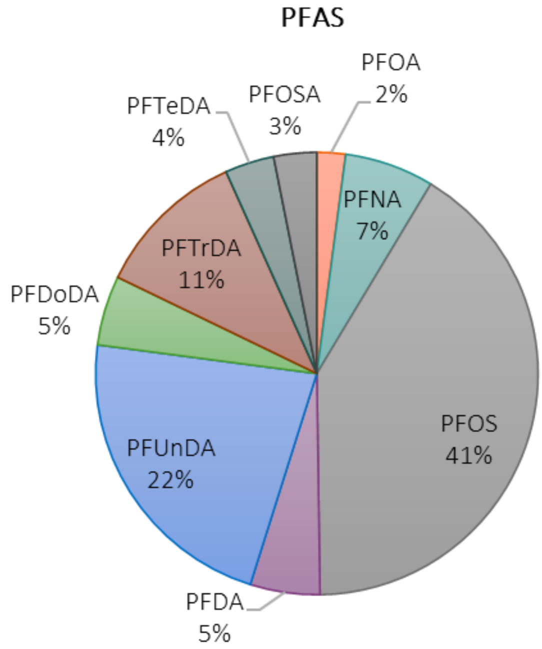

Figure 27. Percentage contribution to the per capita intake of the different PFAS in the Market Basket 2022.

The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating the mean (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was used for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, a lower bound of 0 was used for non-detects when calculating the mean).

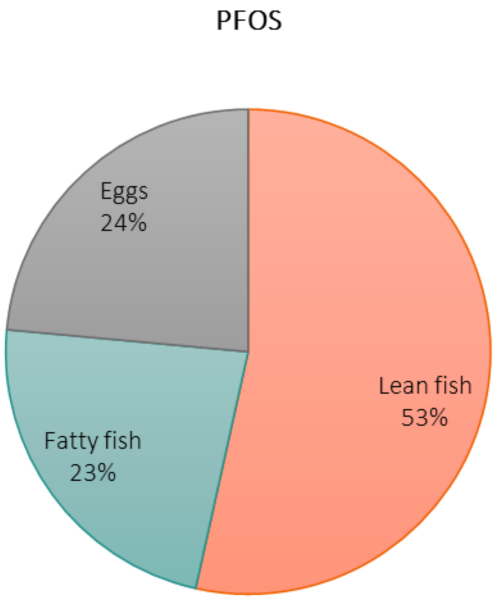

Figure 28. Percentage contribution to the per capita intake of PFOS from food groups in the Market Basket 2022.

In the remaining food groups, all levels were below LOQ and assumed to be 0.

In Figure 29, the temporal trends of the per capita intake of PFAS-4 and ∑PFAS are shown, including the results from the previous market basket studies in 1999, 2005, 2010, and 2015 together with the current one from 2022. The analyses of the samples from 1999 to 2015 were performed by a different laboratory than in 2022. To assess potential differences in analytical methods, re-analyses of historical samples were performed, showing a good conformity between the laboratories, in general. However, for FOSA, the re-analyses showed diverging results, with 7 to 14 times lower levels in the new analyses. FOSA were, therefore, excluded in the temporal trends. Both, the per capita intake of PFAS-4 and ∑PFAS show declining trends. Statistical analyses (log-linear regression) of the temporal trends show an average yearly percent decline of 9.4% for PFAS-4 and 8.2% for ∑PFAS. The decreasing trend in food are in line with temporal trends seen in blood serum in the Swedish population. In children, aged 4, 8 and 12 years, the levels of PFAS-4 showed an average yearly decline of 3-5% between 2008 and 2022 (Lindfeldt et al., 2023). In adult women, the serum level of PFAS-4 had an average decline of 9% per year between 2002 and 2010 and 5% between 2011 and 2022 (Gyllenhammar et al., 2023a).

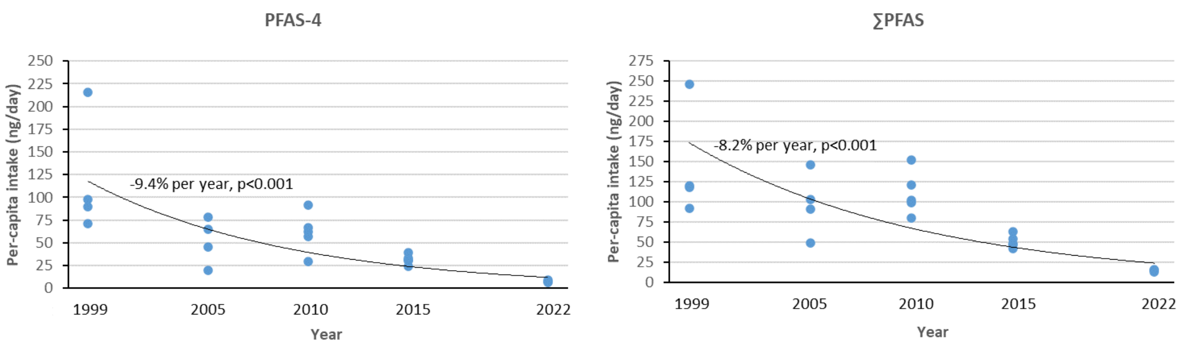

Figure 29. Temporal trends of per capita intake of PFAS-4 and ∑PFAS estimated from market basket studies in Sweden 1999-2022.

Note, that the per capita intake is a function of per capita consumption and concentrations in the food groups. The lines represent regression lines from linear regression analyses with log (ln) transformed per capita intakes. Because of the log transformation, the regression coefficients give the percent change of per capita intake per year. Number of samples per food group was: N=4 (1999 and 2005; pooled samples including four different cities - Gothenburg, Sundsvall, Malmö, Uppsala), N=5 (2010; five different grocery chains in Uppsala; mean of normal and low price baskets from four of the chains and normal price from the fifth chain), N=5 (2015; five grocery chains in Uppsala) and N=3 (2022; three grocery chains in Uppsala).

When comparing the estimated per capita intake from 2022 to the market basket study in 2015 (Swedish Food Agency, 2017), the mean intake was lower in 2022, 7.5 ng/day of PFAS-4 compared to 32 ng/day, and 15 ng/day for ∑PFAS compared to 51 ng/day. There may be several explanations for this. In 2015, PFAS were detected in all analysed groups, except potatoes and soft drinks and the LOQ were also lower in the market basket 2015. The per capita intake of only fish and eggs in the Market Basket 2015, were around half of the total mean intake, at 15 ng/day of PFAS-4 and 24 ng/day of ∑PFAS, but still around 2 times higher than that in 2022.

Comparison of the fish concentrations between the market basket studies is limited by that total fish samples were analyzed in previous market baskets, whereas fish was grouped into lean and fatty fish in the Market Basket 2022. To enable temporal trend analyses, a mean level of fish in 2022 were calculated. The levels of PFAS in fish show declining trends between 1999 and 2022 (see Figure 30). Similar to the temporal trends in Figure 29, the levels of PFOSA were excluded. The concentrations of ∑PFAS in fish decreased significantly between 1999 and 2022 with an average yearly percent decline of 5.3%. The concentrations of PFAS-4 have also decreased, but the linear trend was not significant (p=0.074).

In 2015, the mean level of PFAS-4 in fish at 292 ng/kg was in the same range as in lean fish in 2022 at 304 ng/kg, but lower than in fatty fish at 82 ng/kg. However, for ∑PFAS, the mean level was instead lower in 2015 (504 ng/kg) compared to the level in lean fish 2022 (777 ng/kg), but higher than the level in fatty fish (82 ng/kg). In eggs, the mean level of PFAS-4 was in the same range, at 46 ng/kg in 2015 and 51 ng/kg in 2022, but higher in 2015 including all PFAS, at 65 ng/kg in 2015 and 51 ng/kg in 2022.

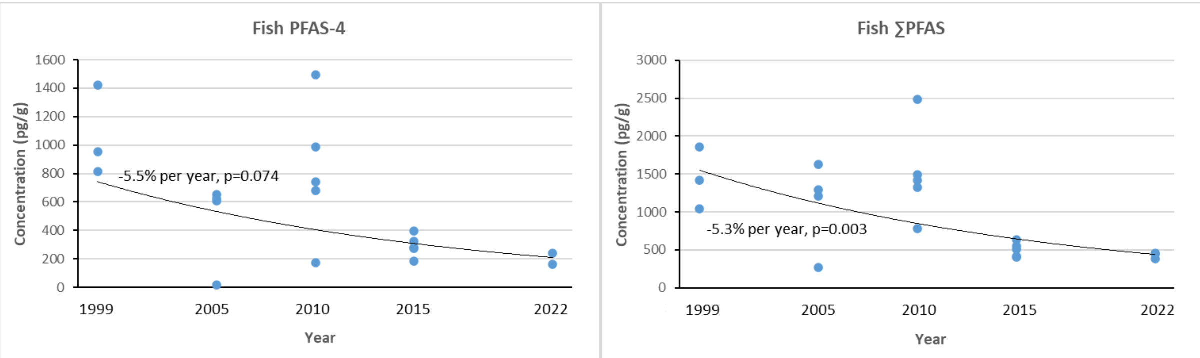

Figure 30. Temporal trends of levels in fish of PFAS-4 and ∑PFAS estimated from market basket studies in Sweden 1999-2022.

The lines represent regression lines from linear regression analyses with log (ln) transformed levels. Following the log transformation, the regression coefficients give the percent change the levels per year. Number of samples per food group was: N=3-4 (1999 (N=3) and 2005 (N=4); pooled samples including four different cities - Gothenburg, Sundsvall, Malmö, Uppsala), N=5 (2010; five different grocery chains in Uppsala; mean of normal and low price baskets from four of the chains and normal price from the fifth chain), N=5 (2015; five grocery chains in Uppsala) and N=3 (2022; three grocery chains in Uppsala). In 2022, a mean concentration of lean and fatty fish was calculated.

Considering the amount consumed, the egg consumption was in the same range between the two studies. For fish, on the other hand, the consumption was 13 g lower in 2022, which might have an impact on the per capita intake. As a sensitivity analysis the fish consumption was set to 37 g/person/day according to statistics of SBA (Swedish Board of Agriculture, 2021b), in line with previous market baskets, instead of 33 g/person/day, to determine whether any major changes occurred. The mean per capita intake would increase to 9 and 17 ng/day for PFAS-4 and ∑PFAS, respectively. This is still being lower compared to the intake in 2015.

8.9.3 Risk assessment

EFSA has in their risk assessment of PFAS in food established a TWI of 4.4 ng PFAS-4/kg bw/week. In the risk assessment, EFSA concludes that PFAS was associated with increased serum cholesterol, decreased birth weight, increased serum alanine aminotransferase and impaired antibody response after vaccination, based on results from epidemiologic studies. The TWI is based on a study of 1-year-old children and associations with a reduced antibody response after vaccination (EFSA, 2020a). The TWI was set at a level that would prevent elevated levels in mothers, that could lead to an exceedance of a safe serum level in their 1-year-old child.

The mean per capita intake of PFAS-4 in the Market Basket 2022 was 0.11 ng/kg bw/day (see Table 30) (assuming a body weight of 70 kg) corresponding to a weekly intake of 0.75 ng/kg bw/week. The estimated intake is well below the TWI, comprising 17% of 4.4 ng/kg bw/week. The intake of PFAS-4 stands for approximately half of the intake of all PFAS detected in the current market basket study. Other PFAS, such as PFUnDA and PFTrDA, contributes substantially to the intake of ∑PFAS indicating that health-based guidance values for more PFAS than PFAS-4 is of importance. Besides food, drinking water can be an important exposure source, mainly in areas where drinking water sources are situated in the vicinity of PFAS contaminated areas (EFSA, 2020a).

8.9.4 Conclusion

Detectable levels of PFAS were found in lean and fatty fish and in eggs, with the highest levels in lean fish. In the remaining food groups, the levels were below the respective LOQs. In lean fish, 9 of the 14 PFAS analysed had detectable levels, whereas fatty fish and eggs only had detectable levels of PFOS. The estimated per capita intake of PFAS-4 in the Market Basket 2022 is below TWI, accounting for 17% of the current TWI set by EFSA. However, PFAS contaminated drinking water could be a significant source of exposure and would increase the weekly intake. The daily per capita intake of PFAS-4 and ∑PFAS show annual declining trends of 8-9% between 1999 and 2022, showing that actions taken to reduce the use of PFAS are of great importance to reduce the exposure from food.

8.10 Chlorinated paraffins (PCAs)

Chlorinated paraffins are complex mixtures mainly composed of polychlorinated n-alkanes (PCAs) (Fernandes et al., 2023). They are produced by the chlorination of paraffins (hydrocarbons) with varying chain lengths resulting in a mixture of thousands of congeners with varying chain-length and chlorination degrees. Historically, they have been grouped into short-chain (C_{10}–C_{13}, SCCPs), medium-chain (C_{14}–C_{17}, MCCPs), and long-chain (C_{18}–C_{30}, LCCPs) chlorinated paraffins. Nowadays, the term chlorinated paraffins is mostly used for the commercial mixtures, while PCAs is used for the more defined polychlorinated n-alkanes that are analysed. Chlorinated paraffins are primarily used as flame retardants, plasticizers in flexible polyvinyl chloride (PVC), and lubricants in metalworking fluids. The production of chlorinated paraffins is increasing, with global production now exceeding 1 million tonnes per year, and China currently being the main producer (Gluge et al., 2016).

Due to their persistence, bioaccumulation potential, and toxicity to aquatic life, PCAs have raised environmental and health concerns. The short-chained PCAs, SCCPs, were listed as a persistent organic pollutant (POP) in the Stockholm Convention on POPs in 2017 and the medium-chained (as MCCPs) were nominated to be listed in 2022. Dietary intake has been identified as the most significant exposure route for the general population, contributing about 60-88% of the total exposure dose of PCAs (Yuan et al., 2022).

The chemical analyses of PCAs were performed by Linköping University, and the analytical method is described in Appendix 4 (section A 4.9). PCAs were analysed in the 17 major food groups included in the Market Basket 2022 as one pooled sample per food group. Cereal samples were processed in triplicates as part of the quality assessment and control. The recovery (%) and LODs (ng/g) for each sample are listed in Table 31.

Table 31. Recovery and method limit of detection (LOD) for PCAs (fresh-weight basis) in the Market Basket 2022.

Food group	Recovery (%)	LOD (ng/g) PCAs-C_{10-13}	LOD (ng/g) PCAs-C_{14-17}	LOD (ng/g) PCAs-C_{18-30}
Cereal products[1]	98-125	6.5-6.6	5.4-5.5	2.3
Pastries	186	16	13	5.7
Meat	109	17	14	5.9
Lean fish	74	11	8.8	3.8
Fatty fish	127	17	14	6.0
Meat substitutes	144	6.6	5.5	2.3
Lean dairy products	98	3.3	2.8	1.2
Fatty dairy products	58	163	135	58
Plant-based drinks	109	2.2	1.8	0.8
Eggs	149	11	8.8	3.8
Fats/oils	102	154	128	55
Vegetables	105	6.5	5.4	2.3
Fruits	68	6.5	5.4	2.3
Potatoes	71	6.5	5.4	2.3
Sugar and sweets	109	33	27	12
Beverages	204	2.2	1.8	0.8
Coffee and tea	108	2.2	1.8	0.8

[1] Three replicates were analysed from the same pooled sample of cereal products.

8.10.1 Concentrations in food groups

Concentrations of PCAs in the different food groups in the Market Basket 2022 are presented in Table 32. The highest ∑PCA levels were detected in pastries and eggs, followed by meat substitutes and meat. For PCAs-C10-13, the highest concentrations were observed in meat, pastries, and eggs. In the case of PCAs-C14-17, the highest levels were found in pastries, meat substitutes, eggs, and fatty fish, while for PCAs-C18-30, the highest concentrations occurred in meat substitutes, eggs, and fatty fish.

The food group sugar/sweets had all values not determined (nd) due to relatively high blank levels. This was also the case for meat substitutes, fatty dairy products, plant-based drinks, beverages, and coffee/tea for PCAs-C_{10-13} and for fatty dairy products and beverages for PCAs-C_{14-17}. In the intake calculations all nd values were set to 0.

Table 32. Concentrations of PCAs (fresh-weight basis) in food groups in the Market Basket 2022 (one pooled sample of the 3 replicates from each food group).

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
PCAs-C_{10-13} (µg/kg)		5.2[1]	18	19	<11	<17	nd	6.3	nd	nd	18	<154	7.5	10	11	nd	nd	nd
PCAs-C_{14-17} (µg/kg)		12[1]	36	16	16	21	27	4.5	nd	<1.8	22	<128	5.9	7.3	7.8	nd	nd	<1.8
PCAs-C_{18-30} (µg/kg)		4.6[1]	8.0	7.8	4.0	12	17	<1.2	<58	<0.8	12	<55	4.0	3.9	3.2	nd	<0.8	<0.8
total PCAs[2] (µg/kg)	LB	22	62	43	20	33	45	11	0	0	51	0	17	22	22	nd	0	0
	MB	22	62	43	25	41	45	11	29	1.3	51	168	17	22	22		0.4	1.3
	UB	22	62	43	30	50		12	58	2.6	51	336	17	22	22		1.3	2.6
PCAs-C_{10-13} Chlorine content (%)		55	56	56	<LOD	<LOD	nd	56	nd	nd	56	<LOD	56	56	56	nd	nd	nd
PCAs-C_{14-17} Chlorine content (%)		52	54	53	55	55	55	46	nd	<LOD	54	<LOD	53	53	54	nd	nd	<LOD
PCAs-C_{18-30} Chlorine content (%)		56	53	51	55	54	54	<LOD	<LOD	<LOD	54	<LOD	55	53	53	nd	<LOD	<LOD

nd, not determined due to high blank levels (nd=0); LOD, limit of detection

[1] Mean of three replicates from the same pool of cereal products.

[2] Sum of all PCAs using lower bound (LB, <LOD=0), medium bound (MB <LOD=0.5*LOD) and upper bound (UB <LOD=LOD).

8.10.2 Exposure estimations

The estimated mean per capita intakes of PCAs-C10-30, and the total PCAs (∑PCAs) are presented in Table 33. The estimated mean per capita intakes in the Swedish population, at MB, were 18, 18, and 10 µg/person/day for PCA-C10-13, PCAs-C14-17 and PCAs-C18-30, respectively. PCAs-C10-13 and PCAs-C14-17 had the highest intakes and contributed to 39 and 40% of the ∑PCAs respectively, while PCAs-C18-30 accounted for 21%, see Figure 31. The estimated mean intake of ∑PCAs was 46 µg/person/day and 0.66 µg/kg bw/day. The mean proportional contribution of each food group to the per capita intakes were similar for the different PCA-groups and ∑PCAs, see Figure 32. Fats/oils contributed the most to the intake of PCAs (15-24%), however levels were <LOD after blank subtraction, and the high intake was caused by high LODs when using MB. This was also the case for fatty dairy products for PCAs-C18-30. The estimated mean intake from meat contributed by 15-20%, pastries 4-11%, cereal product 7-15%, fruits 8-12% and vegetables 8-10% (Figure 32).

The estimated per capita intake of ∑PCAs was about 10 times higher in the Market Basket 2022 compared to 2015. In 2015, the mean per capita intakes at MB were 1.4, 3.0, and 0.15 µg/person/day for PCAs-C10-13, PCAs-C14-17, and PCAs-C18-30, respectively. That could be compared to the estimated MB intakes of 18, 18 and 10 µg/person/day, respectively, in 2022. The difference could be explained by the different labs and analytical methods that were used in the market basket studies and that the LODs were lower in 2015 but it is possible that PCA levels have increased during these years. Higher levels have for example been observed for PCAs-C14-17 in serum from Norwegian women in 2019 compared to 2007-2009 (Xu et al., 2022).

In a study of 61 Norwegian adults, an estimated median dietary intake was reported at 0.16 µg/kg bw/day for ∑PCAs (Yuan et al., 2022), which is about 4 times lower compared to the Market Basket 2022 (0.66 µg/kg bw/day). In studies from China, much higher levels have been detected in food from certain areas, leading to a considerably greater intake compared to this study and intakes in other countries (Chen et al., 2018) (Zhou et al., 2024).

Table 33. Mean daily per capita intake of PCAs (µg/person/day) from different food groups and total intake in the Market Basket 2022 (One pooled sample per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)			
			PCAs-C10-13	PCAs-C14-17	PCAs-C18-30	∑PCAs
Cereal products	226		1.2	2.8	1.0	5.0
Pastries	55		1.0	2.0	0.44	3.4
Meat	194		3.6	3.1	1.5	8.3
Lean fish	15	LB MB UB	0 0.08 0.16	0.23	0.06	0.29 0.37 0.45
Fatty fish	18	LB MB UB	0 0.15 0.30	0.37	0.22	0.59 0.74 0.89
Meat substitutes	3		0	0.08	0.05	0.13
Lean dairy products	248	LB MB UB	1.6	1.1	0 0.15 0.30	2.7 2.8 3.0
Fatty dairy products	70	LB MB UB	0	0	0 2.0 4.0	0 2.0 4.0
Plant-based drinks	13	LB MB UB	0	0 0.01 0.02	0 0.005 0.01	0 0.02 0.03
Eggs	29		0.51	0.63	0.34	1.5
Fats and oils	55	LB MB UB	0 4.2 8.4	0 3.5 7.0	0 1.5 3.0	0 9.2 18
Vegetables	245		1.8	1.4	0.98	4.3
Fruits	215		2.2	1.6	0.84	4.6
Potatoes	142		1.5	1.1	0.45	3.1
Sugar and sweets	74		0	0	0	0
Beverages	262	LB MB UB	0	0	0 0.10 0.21	0 0.10 0.21
Coffee and tea	407	LB MB UB	0	0 0.37 0.73	0 0.16 0.33	0 0.53 1.1
Total		**LB** **MB** **UB**	**13** **18** **22**	**15** **18** **22**	**5.9** **9.9** **14**	**34** **46** **58**
µg/kg bw/day		**MB**	**0.26**	**0.26**	**0.14**	**0.66**

LB, lower bound (i.e. 0 is used for non-detects); MB, medium bound (i.e. 0.5*limit of detection (LOD) is used for non-detects; UB, upper bound (i.e. LOD is used for non-detects). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

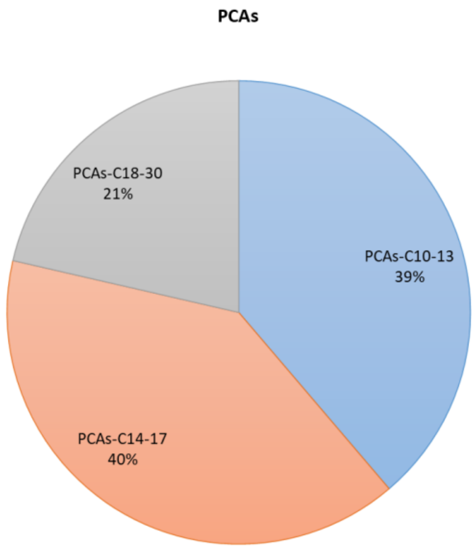

Figure 31. Percentage contribution to the per capita intake of the different PCAs.

The percentage is based on mean per capita intake per food group and medium bound were used when calculating means.

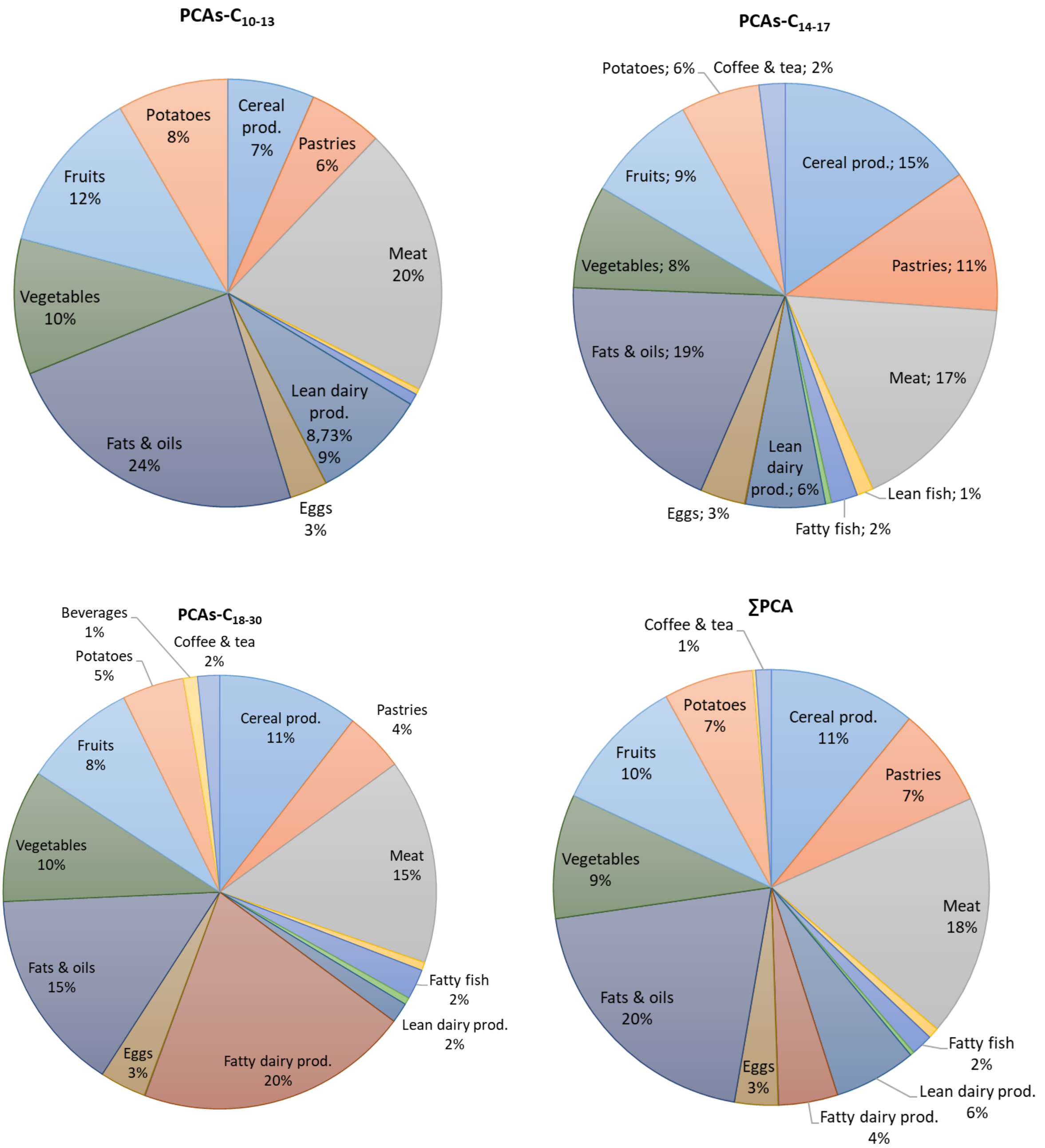

Figure 32. Percentage contribution to the per capita intake of ∑PCAs, PCAs-C10-13, PCAs-C14-17, and PCAs-C18-30 from food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Medium bound were used when calculating means.

8.10.3 Risk assessment

In 2020, EFSA published a risk assessment on chlorinated paraffins in feed and food (EFSA et al., 2020b). EFSA identified the liver, kidneys, and thyroid as the primary target organs in repeated dose toxicity studies in animals, for the tested PCAs-C10-13 and PCAs-C14-17 mixtures. For the tested PCAs-C18-30 mixtures, the liver was identified as the main target organ. For the PCAs-C10-13 and PCAs-C14-17, EFSA derived BMDLs, but no reference point was set for PCAs-C18-30 because of insufficient data. For PCAs-C10-13, a BMDL was set to 2 300 µg/kg bw/day for increased incidence of nephritis and PCAs-C14-17 to 36 000 µg/kg bw/day for increased relative kidney weights. EFSA concluded that there might be no health concern at an MOE greater than 1 000, considering species variability (factor of 10), individual human variability (factor of 10), and the extrapolation from sub chronic to chronic exposure (factor of 2). The MOE in the Market Basket 2022 for PCAs-C10-13 was around 9 000 for MB (LB 12 000 and UB 7 200) and for PCAs-C14-17 around 137 000 for MB (LB 174 000 and UB 113 000). As the MOE were higher than 1 000 also for the intakes of PCAs-C10-13 and PCAs-C14-17 at UB, the results indicates that the Swedish population is likely not at risk for effects of PCAs through dietary exposure.

8.10.4 Conclusion

PCAs were analysed in a pooled sample from each of the 17 major food groups, categorized into short- (PCAs-C10-13), medium- (PCAs-C14-17), and long-chained (PCAs-C18-30) PCAs. The highest concentrations of ∑PCAs were found in pastries and eggs, followed by meat substitutes and meat. The mean per capita intake was 18 µg/person/day for both short- and medium-chained PCAs, and 10 µg/person/day for long-chained PCAs. The total estimated per capita intake of all PCAs was 0.66 µg/kg bw/day. Fats/oils contributed the most to PCA intake, although this was influenced by high LODs in the MB calculations. Apart from fats/oils, also meat, pastries, cereal products, fruits, and vegetables were the largest contributors to the overall intake. The total per capita intake of PCAs in 2022 was around 10 times higher than in the Market Basket 2015, which may be due to differences in analytical methods, but could also reflect increased concentrations in food. The risk assessment indicated a significant margin between the estimated per capita intakes and the reference points, resulting in high MOEs and concluding no health concerns.

8.11 Organophosphate flame retardants (PFRs)

Organophosphate flame retardants (PFRs) are used as flame retardants in products such as electronics, textiles, furniture, and industrial materials to prevent the risk of fire and have become widely used as alternatives to PBDEs. PFRs can also be used as plasticizers and is primarily used in PVC. PFRs have been used for several decades and have been found in the environment and biota. Food intake has been concluded to be an important exposure source for PFRs although humans could also be exposed through inhalation of air and dust, and dermal uptake (Poma et al., 2017, Gbadamosi et al., 2021). In total, 17 PFRs (see Table 34) were analysed in the 17 major food groups included in the Market Basket 2022. The chemical analyses were performed at the University of Antwerp, and the analytical method is described in Appendix 4 (section A 4.10). All substances were analysed using LC-MS/MS and all samples were freeze-dried prior to extraction, except for the food groups fats/oils and sugar/sweets. All analysed PFRs with LOQs, detection frequencies and accuracies of the quality control are listed in Table 34. LOQs differed between food groups depending on weight of samples and the wet content.

Table 34. Limits of quantification (LOQ), detection frequency (DF), accuracy of spiked samples (n=4) and the relative standard deviation (RSD) for determination of PFRs in the Market Basket 2022.

Substance	Full name	LOQ (µg/kg)	DF (%)	Accuracy (%)	RSD (%)
TEP	Triethyl phosphate	0.01-8	4	13	58
TCEP	Tris(2-chloroethyl) phosphate	0.05-2	4	94	8
TCIPP	Tris(chloro-2-propyl) phosphate	0.2-12.5	27	115	29
TiBP	Tri-iso-butyl phosphate	0.02-2	59	74	4
TDCIPP	Tris(1,3-dichloro-2-propyl) phosphate	0.5-30	4	97	3
TnBP	Tri-N-butyl phosphate	0.02-2	39	97	5
V6	2,2-bis(chloromethyl)-propane-1,3-diyltetrakis(2-chloroethyl) biphosphate	0.01-0.5	18	42	40
TPhP	Triphenyl phosphate	0.01-1	27	96	4
TBOEP	Tris(2-butoxyethyl) phosphate	0.01-1	35	104	8
TDBPP	Tris(2,3-dibromopropyl) phosphate	0.01-0.5	8	53	14
EHDPHP	2-ethylhexyl diphenyl phosphate	0.02-2	65	101	6
TpTP	Tricresyl phosphate	0.01-0.5	25	96	10
iDPP	Isodecyl diphenyl phosphate	0.01-1	22	80	8
RDP	Resorcinol bis(diphenylphosphate)	0.01-0.5	24	95	22
TEHP	Tris(2-ethylhexyl) phosphate	0.01-0.5	43	148	12
TBuPHP	Tris(4-tert-butylphenyl) phosphate	0.01-0.5	25	174	17
BDP	Bisphenol A - bis(diphenyl phosphate)	0.05-5	2	122	34

8.11.1 Concentrations in food groups

Concentrations of PFRs in the different food groups in the Market Basket 2022 are presented in Table 35. Several PFRs had concentrations below their respective LOQ. EHDPHP had the highest detection frequency (65%) and was detected in all food groups except for lean and fatty dairy products and eggs, followed by TiBP (59%) that was detected in all food groups except vegetables. TEP, TCEP, TDCIPP and BDP had the lowest detection frequency of only 2-4% and were detected in only 1 or 2 food groups. Highest levels of ∑PFRs were found in fatty dairy products followed by pastries, meat substitute, fruits, fats/oils, and sugar/sweets. The food groups with the highest concentrations of PFRs were generally more processed foods compared to other food groups, suggesting that contamination may occur during food processing, confirming what was shown in previous studies (Poma et al., 2018, Gbadamosi et al., 2022). Meat substitutes and plant-based drinks did also have higher levels compared to meat and lean dairy products which could be speculated to be caused by contamination during the processing of the foods, since meat substitutes and plant-based drinks do include items that are heavily processed. Lean dairy products, beverages, lean fish, and coffee/tea had the lowest concentrations of ∑PFRs. Fatty fish and fatty dairy products had respectively around 20 and 130-times higher concentrations of ∑PFRs (HB) compared to lean fish and lean dairy products, indicating that food products with high fat content can be more contaminated with PFRs.

Table 35. Concentrations of PFRs in food groups in the Market Basket 2022 (N=3 per food group).

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
TEP	Mean	0	2.4	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0
(µg/kg)	Min	<5.5	<1.5	<2.5	<1.5	<3.0	<3.0	<1.0	<4.0	<1.0	<2.0	<8.0	<1.0	<2.0	<2.0	<3.5	<1.5	<0.01
	Median	<5.5	<1.5	<2.5	<1.5	<3.0	<3.0	<1.0	<4.0	<1.0	<2.0	<8.0	<1.0	<2.0	<2.0	<3.5	<1.5	<0.01
	Max	<5.5	5.8	<2.5	<1.5	<3.0	<3.0	<1.0	<4.0	<1.0	<2.0	<8.0	<1.0	2.7	<2.0	<3.5	<1.5	<0.01
TCEP	Mean	0	4.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(µg/kg)	Min	<1.5	<1.5	<1.0	<0.50	<1.0	<1.0	<0.50	<1.0	<0.50	<0.50	<2.0	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50
	Median	<1.5	5.2	<1.0	<0.50	<1.0	<1.0	<0.50	<1.0	<0.50	<0.50	<2.0	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50
	Max	<1.5	6.7	<1.0	<0.50	<1.0	<1.0	<0.50	<1.0	<0.50	<0.50	<2.0	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50
TCIPP	Mean	0	0	0	0	0	2.8	0	7.6	2.3	2.2	14	1.5	13	4.8	9.6	0	0
(µg/kg)	Min	<9.0	<9.5	<4.0	<2.5	<4.5	<4.0	<1.5	<6.5	<2.0	<3.0	<12.5	<2.0	8.9	<3.0	<6.0	<2.0	<0.20
	Median	<9.0	<9.5	<4.0	<2.5	<4.5	<5.0	<1.5	<6.5	2.5	<3.0	16	<2.0	13	5.5	<6.0	<2.0	<0.20
	Max	<9.0	<9.5	<4.0	<2.5	<4.5	3.9	<1.5	16	3.5	3.5	18	2.5	17	7.2	23	<2.0	<0.20
TiBP	Mean	1.3	5.4	1.1	0.44	1.3	1.1	0.18	1.4	0.22	1.1	4.0	0	1.9	1.6	3.0	0.34	0.11
(µg/kg)	Min	<1.5	<1.5	<1.0	<0.50	1.1	<1.0	<0.20	<1.0	<0.25	<0.50	2.5	<0.50	1.3	<0.50	2.2	<0.50	0.01
	Median	<1.5	3.2	1.4	<0.50	1.2	1.2	<0.20	<1.0	<0.25	<0.50	4.7	<0.50	2.0	1.5	2.9	<0.50	0.11
	Max	2.3	12	1.5	0.83	1.5	1.8	0.34	3.3	0.41	2.8	4.9	<0.50	2.5	3.2	3.9	0.51	0.22
TDCIPP	Mean	0	0	0	0	13	0	0	0	0	0	0	0	15	0	0	0	0
(µg/kg)	Min	<30	<30	<15	<10	<15	<15	<5.0	<20	<5.0	<10	<2.0	<5.0	<10	<10	<1.0	<6.0	<0.50
	Median	<30	<30	<15	<10	<15	<15	<5.0	<20	<5.0	<10	<2.0	<5.0	<10	<10	<1.0	<6.0	<0.50
	Max	<30	<30	<15	<10	23	<15	<5.0	<20	<5.0	<10	<2.0	<5.0	34	<10	<1.0	<6.0	<0.50
TnBP	Mean	0	4.6	0	0	0	1.3	0	1.4	0.43	1.0	5.6	0.34	2.3	1.0	4.3	0	0.17
(µg/kg)	Min	<1.5	<1.5	<1.0	<0.50	<1.0	<1.0	<0.50	<1.0	<0.50	<0.50	3.8	<0.50	2.0	<0.50	1.5	<0.50	0.11
	Median	<1.5	<1.5	<1.0	<0.50	<1.0	<1.0	<0.50	1.3	<0.50	<0.50	5.0	<0.50	2.4	<0.50	5.2	<0.50	0.11
	Max	<1.5	12	<1.0	<0.50	<1.0	2.8	<0.50	2.5	0.79	2.5	8.0	0.51	2.5	2.5	6.3	<0.50	0.29
V6	Mean	0	3.0	0	0	0	0	0	0.14	0	0	0.87	0	0	0	0	0	0.01
(µg/kg)	Min	<0.50	0.62	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20	<0.10	<0.20	0.58	<0.10	<0.20	<0.20	<0.30	<0.10	<0.01
	Median	<0.50	4.1	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20	<0.10	<0.20	0.80	<0.10	<0.20	<0.20	<0.30	<0.10	0.01
	Max	<0.50	4.3	<0.20	<0.10	<0.20	<0.20	<0.10	0.23	<0.10	<0.20	1.2	<0.10	<0.20	<0.20	<0.30	<0.10	0.02
TPhP	Mean	0	1.6	0.64	0	0.94	3.3	0.07	0	0	0	0.75	0	0	0	0.33	0	0.01
(µg/kg)	Min	<1.0	<1.0	<0.50	<0.20	<0.50	1.8	<0.10	<0.50	<0.20	<0.30	<1.0	<0.20	<0.30	<0.30	<0.50	<0.20	<0.01

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
	Median	<1.0	1.8	0.52	<0.20	1.2	2.4	<0.10	<0.50	<0.20	<0.30	<1.0	<0.20	<0.30	<0.30	<0.50	<0.20	<0.01
	Max	<1.0	2.4	1.2	<0.20	1.3	5.7	0.11	<0.50	<0.20	<0.30	1.2	0.7	<0.30	<0.30	0.50	<0.20	0.01
TBOEP (µg/kg)	Mean	0	3.5	0.37	0	0.37	0.35	0.19	0.46	0.10	0.44	2.2	0.11	0.31	0	1.6	0	0.02
	Min	<1.0	<1.0	<0.30	<0.20	<0.50	<0.50	<0.10	<0.50	<0.15	<0.50	<1.0	<0.15	<0.3	<0.30	0.81	<0.20	<0.01
	Median	<1.0	3.5	0.46	<0.20	<0.50	<0.50	<0.10	<0.50	<0.15	<0.50	2.9	<0.15	<0.3	<0.30	0.91	<0.20	<0.01
	Max	<1.0	6.6	0.50	<0.20	0.60	0.55	0.48	0.88	0.15	0.83	3.2	0.18	0.64	<0.30	3.2	<0.20	0.05
TDBPP (µg/kg)	Mean	0	0.48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.67
	Min	<0.50	<0.40	<0.20	<0.10	<0.20	<0.20	<0.10	<0.50	<0.10	<0.20	<0.50	<0.10	<0.20	<0.20	<0.30	<0.10	<0.01
	Median	<0.50	0.48	<0.20	<0.10	<0.20	<0.20	<0.10	<0.50	<0.10	<0.20	<0.50	<0.10	<0.20	<0.20	<0.30	<0.10	0.01
	Max	<0.50	0.77	<0.20	<0.10	<0.20	<0.20	<0.10	<0.50	<0.10	<0.20	<0.50	<0.10	<0.20	<0.20	<0.30	<0.10	2.0
EHDPHP (µg/kg)	Mean	6.5	16	5.7	0.48	3.3	19	0	0	0.71	0	1.9	4.5	0.88	1.3	6.7	0.20	0.01
	Min	3.2	11	<1.0	<0.50	1.2	5.0	<0.20	<1.0	0.49	<0.50	<2.0	1.0	0.61	<0.50	4.0	<0.15	<0.02
	Median	4.4	12	4.0	<0.50	2.4	23	<0.20	<1.0	0.70	<0.50	<2.0	1.2	0.87	1.8	4.5	0.13	<0.02
	Max	12	25	13	0.93	6.2	29	<0.20	<1.0	0.95	<0.50	3.7	11	1.2	1.8	12	0.40	0.02
TpTP (µg/kg)	Mean	0	0.63	0.27	0	0.23	2.2	0	0	0	0	0.49	0.05	0	0	0.17	0	0.01
	Min	<0.50	<0.50	<0.15	<0.10	<0.20	0.61	<0.10	<0.30	<0.10	<0.15	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Median	<0.50	0.74	0.18	<0.10	0.18	0.87	<0.10	<0.30	<0.10	<0.15	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Max	<0.50	0.90	0.56	<0.10	0.39	5.2	<0.10	<0.30	<0.10	<0.15	0.96	0.05	<0.15	<0.15	0.26	<0.10	0.01
iDPP (µg/kg)	Mean	0	1.1	0.96	0	0.23	0.92	0	0	0	0	0	0.12	0	0.14	0	0	0
	Min	<1.0	<1.0	0.59	<0.20	<0.35	0.42	<0.10	<0.50	<0.15	<0.25	<1.0	<0.15	<0.25	<0.20	<0.50	<0.15	<0.01
	Median	<1.0	1.2	1.1	<0.20	<0.35	0.85	<0.10	<0.50	<0.15	<0.25	<1.0	<0.15	<0.25	<0.20	<0.50	<0.15	<0.01
	Max	<1.0	1.5	1.2	<0.20	0.35	1.5	<0.10	<0.50	<0.15	<0.25	<1.0	0.22	<0.25	0.23	<0.50	<0.15	<0.01
RDP (µg/kg)	Mean	0	1.3	0.64	0	0.14	0.52	0	0	0	0	0.48	0.07	0.10	0	0	0	0.01
	Min	<0.50	<0.50	<0.20	<0.10	<0.20	0.25	<0.10	<0.25	<0.10	<0.15	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Median	<0.50	1.8	0.51	<0.10	<0.20	0.49	<0.10	<0.25	<0.10	<0.15	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Max	<0.50	1.8	1.3	<0.10	0.21	0.81	<0.10	<0.25	<0.10	<0.15	0.93	0.11	0.16	<0.15	<0.25	<0.10	0.01
TEHP (µg/kg)	Mean	0	3.1	2.3	0.14	0.62	3.0	0	46	0	0	1.9	0.07	0.42	0.11	0	0	0
	Min	<0.40	1.0	1.8	0.12	<0.20	1.4	<0.05	<0.25	<0.10	<0.15	<0.50	<0.10	0.24	<0.15	<0.25	<0.10	<0.01
	Median	<0.40	4.0	1.9	0.15	0.70	2.4	<0.05	<0.25	<0.10	<0.15	0.88	<0.10	0.42	<0.15	<0.25	<0.10	<0.01
	Max	<0.40	4.3	3.2	0.15	1.1	5.1	<0.05	138	<0.10	<0.15	4.5	0.11	0.60	0.19	<0.25	<0.10	<0.01
TBuPhP (µg/kg)	Mean	0	2.8	0.85	0	0.27	0.27	0	0	0	0	0.51	0	0	0	0.20	0	0
	Min	<0.50	0.62	<0.20	<0.10	<0.20	0.16	<0.10	<0.25	<0.10	<0.15	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Median	<0.50	3.7	0.80	<0.10	0.35	0.29	<0.10	<0.25	<0.10	<0.15	0.55	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Max	<0.50	4.2	1.6	<0.10	0.36	0.37	<0.10	<0.25	<0.10	<0.15	0.72	<0.10	<0.15	<0.15	0.34	<0.10	<0.01

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
BDP	Mean	0	0	1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(µg/kg)	Min	<3.5	<4.0	<1.5	<1.0	<2.0	<2.0	<1.0	<2.5	<0.75	<1.5	<5.0	<1.0	<1.5	<1.5	<2.5	<0.75	<0.05
	Median	<3.5	<4.0	<1.5	<1.0	<2.0	<2.0	<1.0	<2.5	<0.75	<1.5	<5.0	<1.0	<1.5	<1.5	<2.5	<0.75	<0.05
	Max	<3.5	<4.0	2.0	<1.0	<2.0	<2.0	<1.0	<2.5	<0.75	<1.5	<5.0	<1.0	<1.5	<1.5	<2.5	<0.75	<0.05
∑PFRs[1]	Mean	7.3	48	13	0.72	14	32	0.31	54	3.2	3.2	28	5.8	31	8.0	24	0.35	0.99
LB	Min	3.2	14	3.8	0.12	7.1	22	0.11	2.4	0.49	0	25	1.1	17	1.8	12	0	0.17
(µg/kg)	Median	6.8	62	11	0.97	11	31	0.34	22	4.1	0	29	1.9	24	9.0	23	0.40	0.54
	Max	12	68	24	1.1	25	44	0.48	138	4.9	9.6	31	15	53	13	36	0.64	2.3
∑PFRs[2]	Mean	7.8	51	14	1.1	20	35	0.44	57	3.8	4.7	32	6.9	32	8.9	26	0.54	1.0
HB	Min	4.0	21	6.2	0.62	15	23	0.26	6.3	1.9	2.3	32	2.7	17	4.0	15	0.33	0.19
(µg/kg)	Median	6.8	63	12	1.2	19	33	0.44	23	4.2	2.3	32	3.2	25	9.3	27	0.64	0.56
	Max	13	70	24	1.3	26	47	0.63	142	5.2	9.6	33	15	54	13	36	0.65	2.3

< indicates a value below limit of quantification (LOQ). A hybrid bound approach was used when the means were calculated, i.e. concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero). Abbreviations of PFRs are referred to Table 34.

[1] Sum of all PFRs using lower bound (LB, <LOQ=0).

[2] Sum of all PFRs using hybrid bound (medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

8.11.2 Exposure estimations and time trends

The estimated mean per capita intakes in the Swedish population ranged from 0.15 to 6 µg/person/day for the different PFRs. The PFRs with a detection frequency >50% (TiBP and EHDPHP) and ∑PFRs are presented in Table 36. Since many PFRs had concentrations below LOQ, per capita intake of ∑PFRs was calculated using LB and HB approaches only (not UB). TCIPP, EHDPHP, TEHP, and TCDIPP had the highest mean per capita intakes (6.0, 5.7, 4.1, and 3.4 µg/person/day, respectively) and contributed 13-22% of the ∑PFRs. The proportional contributions of different PFRs to the mean per capita intake are presented in Figure 33. The estimated mean intake of ∑PFRs was 27 µg/person/day and 0.39 µg/kg bw/day. Fruit contributed the most to the intake of ∑PFRs (26%), followed by fatty dairy products (15%), pastries (11%), and meat (10%). The fruit group included not only fresh fruit but also processed foods like canned and dried fruits, nuts, juice, and jam, which may explain the relatively high concentration of ∑PFRs. The mean proportional contribution of each food group to the per capita intakes of TiBP, EHDPHP, and ∑PFRs are presented in Figure 34. The contribution from different food groups varied between the PFRs and no clear trend was found.

The estimated total per capita intakes of PFRs from the market basket studies 2015 and 2022 are presented in Figure 35. The total intake was about 5 times higher in the Market Basket 2022 compared to 2015. In 2022, 17 PFRs were analysed in the food groups but in 2015, only 8 compounds were included in the analysis. However, when the total intake for the 8 PFRs analysed both in 2015 and 2022 were compared, the intake in 2022 was still 5 times higher than in 2015. The difference could be explained by the different analytical methods that were used in the market basket studies but it could also show an increasing trend and that more PFRs are used during recent years. No increase in urine levels of metabolites to TiBP, TPhP, and TBOEP have been observed in Swedish first-time mothers between 2009-2021 or for TDCIPP between 2019-2021 (Gyllenhammar et al., 2023b).

Table 36. Mean daily per capita intake of PFRs (µg/person/day) from different food groups and total intake in the Market Basket 2022 (N=3 per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)		
			TiBP	EHDPHP	∑PFRs[1]
		LB	0.17		1.6
Cereal products	226	HB	0.29	1.5	1.8
		UB	0.40		
		LB	0.29		2.6
Pastries	55	HB	0.30	0.88	2.8
		UB	0.31		
		LB	0.19	1.1	2.5
Meat	194	HB	0.22	1.1	2.7
		UB	0.25	1.1	
		LB	0.004	0.005	0.01
Lean fish	15	HB	0.007	0.007	0.02
		UB	0.009	0.01	
		LB			0.26
Fatty fish	18	HB	0.02	0.06	0.36
		UB			
		LB	0.003		0.10
Meat substitutes	3	HB	0.003	0.06	0.10
		UB	0.004		
		LB	0.03	0	0.08
Lean dairy products	248	HB	0.05	0	0.11
		UB	0.06	0.05	
		LB	0.08	0	3.8
Fatty dairy products	70	HB	0.10	0	4.0
		UB	0.12	0.07	
		LB	0.002		0.04
Plant-based drinks	13	HB	0.003	0.009	0.05
		UB	0.004		
		LB	0.03	0	0.09
Eggs	29	HB	0.03	0	0.14
		UB	0.04	0.01	
		LB		0.007	1.6
Fats and oils	55	HB	0.22	0.10	1.8
		UB		0.14	
		LB	0		1.4
Vegetables	245	HB	0	1.1	1.7
		UB	0.12		
		LB			6.7
Fruits	215	HB	0.42	0.19	7.6
		UB			
		LB	0.22	0.17	1.1
Potatoes	142	HB	0.23	0.18	1.3
		UB	0.25	0.19	
		LB			1.8
Sugar and sweets	74	HB	0.22	0.51	1.9
		UB			

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)		
			TiBP	EHDPHP	∑PFRs[1]
Beverages	262	LB	0.04	0.05	0.09
		HB	0.09	0.05	0.14
		UB	0.13	0.06	
Coffee and tea	407	LB		0.002	0.40
		HB	0.04	0.005	0.41
		UB		0.008	
Total		**LB**	**2.0**	**5.7**	**24**
		HB	**2.2**	**5.7**	**27**
		UB	**2.6**	**6.0**	
µg/kg bw/day		**HB**	**0.03**	**0.08**	**0.38**

Abbreviations of PFRs are referred to Table 34. LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

[1] Because many PFRs had concentrations below LOQ, per capita intake of ∑PFRs was calculated using LB and HB approaches only (not UB).

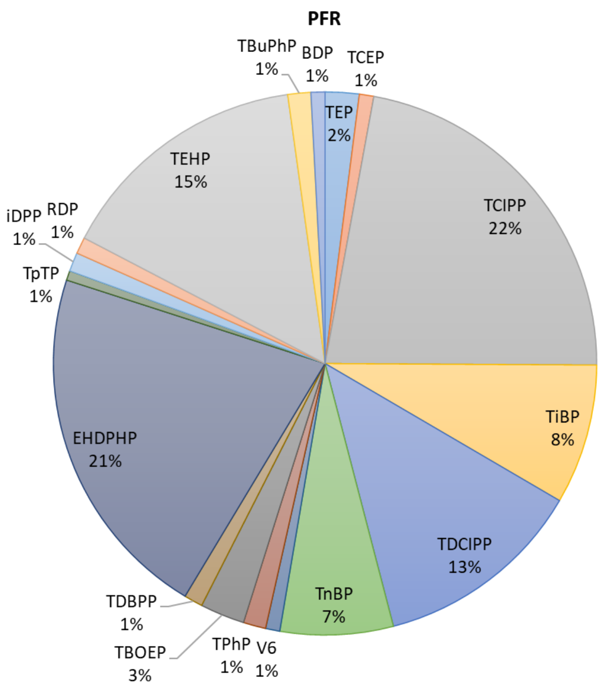

Figure 33. Percentage contribution to the per capita intake of the different PFRs.

The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

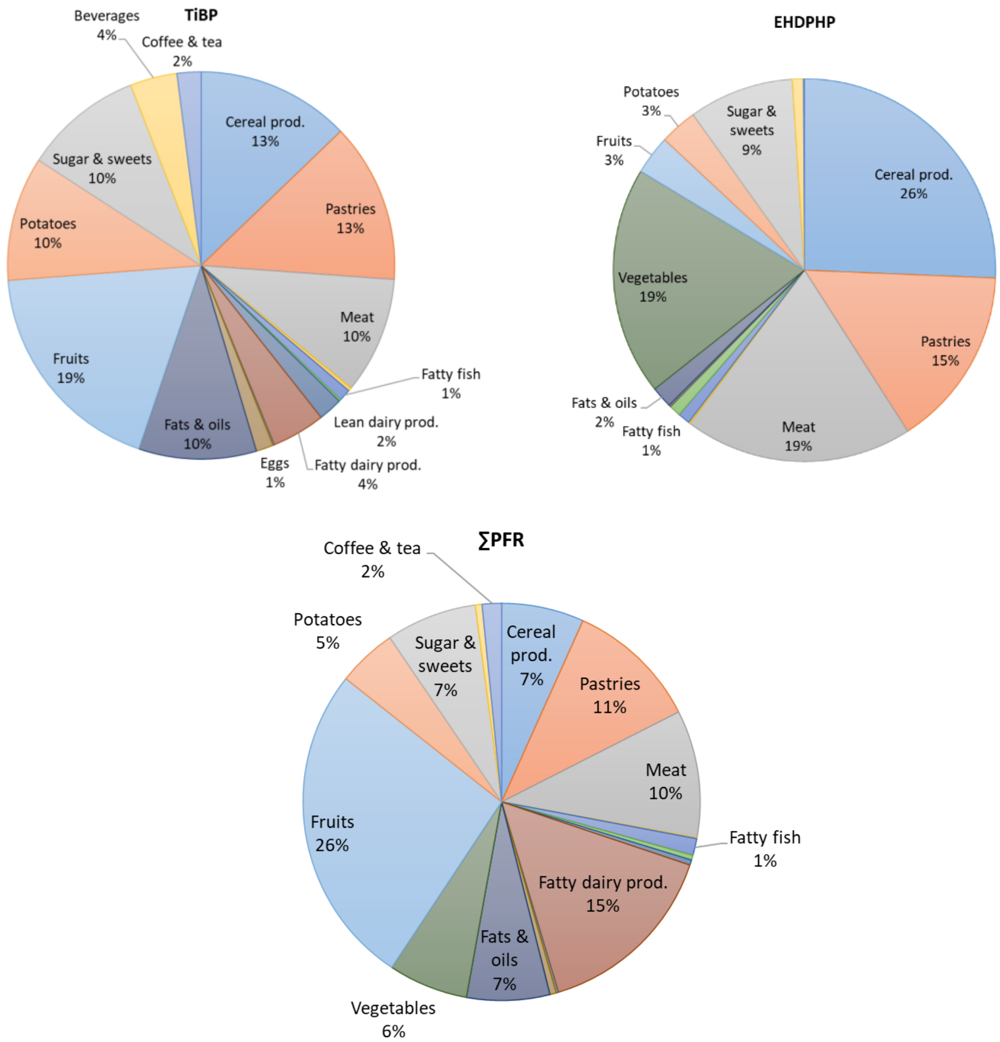

Figure 34. Percentage contribution to the per capita intake of TiBP, EHDPHP and the ∑PFRs from food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

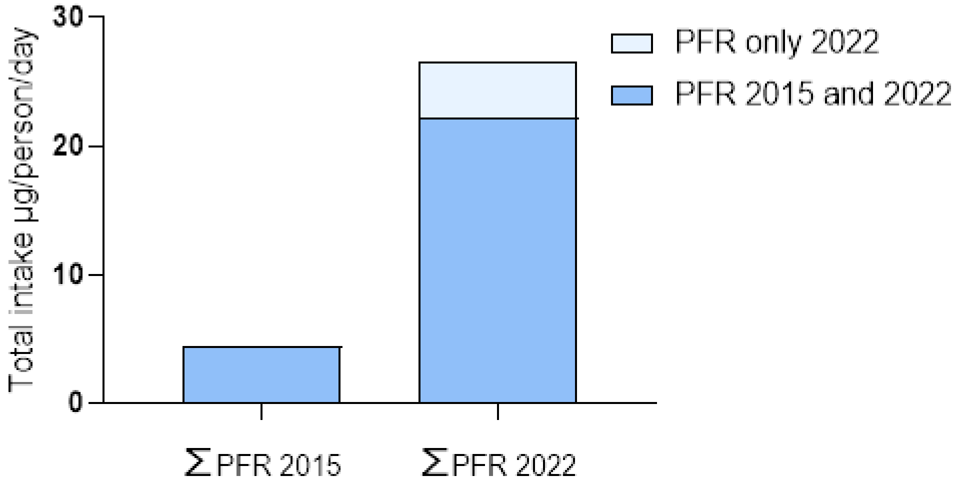

Figure 35. Mean total daily per capita intake of ∑ PFRs (µg/person/day) from the Market Basket 2015 and 2022.

Dark blue represents the 8 PFRs that were analysed both in 2015 and 2022 and the light blue represents the additional 9 PFRs that was only analysed in 2022.

8.11.3 Risk assessment

The estimated per capita intakes were compared to reference doses for PFRs reported in three publications (Ali et al., 2012, Poma et al., 2018, Li et al., 2019). Out of the 17 PFRs analysed in the Market Basket 2022, 9 compounds (TEP, TCEP, TCIPP, TnBP, TPhP, TBOEP, EHDPHP, TpTP, and TEHP) have reference doses that could be compared with the estimated per capita intakes. The reported reference doses ranged between 7 and 125 µg/kg bw/day and could be compared to the estimated per capita intake of the 9 PFRs ranging from 0.002 to 0.085 µg/kg bw/day. Hence, the per capita intakes were 120-16,000 times lower compared to the reference doses, showing that the Swedish population is likely not at risk for adverse effects of PRFs through dietary exposure. Even though food intake is considered the main exposure source for PFRs, there are other exposure ways, such as dust and air inhalation and dermal exposure. It is therefore possible that the total daily exposure would increase if these exposure routes were included as well but would not likely exceed the reference doses.

8.11.4 Conclusion

In total, 17 PFRs were analysed in the Market Basket 2022 with a detection frequency of 2-65%. EHDPHP and TiBP had the highest detection frequencies. Highest levels of ∑PFRs were found in fatty dairy products, followed by pastries, meat substitute, fruits, fats/oils, and sugar/sweets. The mean per capita intakes were ranging from 0.15 to 6 µg/person/day for the different PFRs and the total intake of all PFRs was 27 µg/person/day. TCIPP contributed most to the per capita intake, followed by EHDPHP, TEHP and TCDIPP. Fruit contributed the most to the intake of ∑PFRs, followed by fatty dairy products, pastries, and meat. The total per capita intake of PFRs was higher in 2022 compared to the market basket study in 2015, which could be explained by the different analytical methods used, but it could also show an increasing trend of use of these substances. The risk assessment showed a large margin between the estimated per capita intakes and the reference doses.

8.12 Plasticizers

Plasticizers are additives to plastics used to increase the flexibility and lifetime of the material. Food intake is one exposure source for plasticizers, but humans are also exposed through inhalation of air, ingestion of dust, and use of personal care products. In total, 20 plasticizers (see Table 37) were analysed in the 17 major food groups included in the Market Basket 2022. Both legacy phthalates and alternative plasticizers were included. The chemical analyses were performed at the University of Antwerp, and the analytical method is described in Appendix 4 (section A 4.10). All substances were analysed using LC-MS/MS, except for DEHP and DEHT for which GC-MS/MS was used. All samples were freeze-dried prior to extraction, except for the food groups fats/oils, and sugar/sweets. All analysed plasticizers with LOQs, detection frequencies and accuracies of the quality control are listed in Table 37. LOQs differed between food groups depending on weight of samples and the wet content.

Table 37. Limits of quantification (LOQ), detection frequency (DF), accuracy of spiked samples (n=4) and the relative standard deviation (RSD) for determination of plasticizers in the Market Basket 2022.

Substance	Full name	LOQ (µg/kg)	DF (%)	Accuracy (%)	RSD (%)
DMP	Dimethyl phthalate	0.05-3	71	33	25
DEP	Diethyl phthalate	0.5-45	55	122	13
DnBP	Di-N-butyl phthalate	1.5-150	2	106	4
DPP	Diphenyl phthalate	0.01-0.5	33	74	14
BBzP	Benzyl butyl phthalate	0.05-2.5	35	118	2
ATEC	Acetyltriethyl citrate	0.01-0.5	47	166	9
DIBA	Di-iso-butyl adipate	0.01-1	37	100	19
CDPHP	Cresyl diphenyl phosphate	0.01-1	65	124	13
ATBC	Acetyltributyl citrate	1.75-150	31	148	6
DBS	Dibutyl sebacate	0.5-50	10	146	7
DEHA	Diethylhexyl adipate	0.5-60	31	125	8
BTHC	Butyryl trihexyl citrate	0.05-3	2	124	12
THTM	Tri-n-hexyl trimellitate	0.01-1	2	104	3
TOTM	Tris(2-ethylhexyl) trimellitate	0.1-7.5	6	35	19
DiBP	Di-iso-butyl phthalate	0.25-30	39	107	4
DINP	Di-iso-nonyl phthalate	2.5-225	12	-	-
DINCH	1,2- Cyclohexane dicarboxylic acid diisononyl ester	0.15-12.5	16	-	-
DIDP	Di-iso-decyl phthalate	0.4-40	0	-	-
DEHP	Bis(2-ethylhexyl) phthalate	5-500	6	95	7
DEHT	Bis(2-ethylhexyl) terephthalate	2.5-200	4	104	22

8.12.1 Concentrations in food groups

Concentrations of plasticizers in the different food groups in the Market Basket 2022 are presented in Table 38. Several plasticizers had levels below LOQ. The three plasticizers with the highest detection frequencies were DMP (71%), CDPHP (65%), and DEP (55%). DMP was detected in all food groups except for cereal products, beverages, and coffee/tea. CDPHP was not detected in fats/oils, sugar/sweets and beverages. DEP was not detected in pastries, lean fish, lean dairy products, beverages, and coffee/tea. DIDP was not detected in any of the samples. DnBP, BTHC, THTM, TOTM, DEHP, and DEHT had a detection frequency of only 2-6% and were detected in only one food group, except for TOTM that was detected in three.

Highest levels of the ∑plasticizers were found in fatty dairy products, followed by meat substitutes, fats/oils, fatty fish and cereal products. Beverages, lean fish and coffee/tea had the lowest concentrations of ∑plasticizers. Contamination of food with plasticizers may occur during food processing and there was a tendency for higher concentrations in food groups with generally more processed foods. Fatty fish and fatty dairy products had respectively about 80 and 40 times higher concentrations of ∑plasticizers (HB) compared to lean fish and lean dairy products. These results indicate that foods with high fat content are more contaminated with plasticizers and it has been shown that migration of phthalates from packaging into foods is promoted if the food product have a high fat percentage (da Costa et al., 2023).

Table 38. Concentrations of plasticizers in food groups in the Market Basket 2022 (N=3 per food group).

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
DMP (µg/kg)	Mean	0	3.4	2.7	0.97	4.8	7.3	0.46	2.7	0.93	2.8	6.1	0.42	1.7	0.71	3.0	0	0
	Min	<2.0	2.4	<1.0	0.87	1.8	6.4	0.41	<1.5	0.67	1.6	<2.5	<0.50	1.5	<0.75	2.1	<0.50	<0.05
	Median	<2.0	3.6	3.6	0.98	4.1	6.4	0.47	3.5	0.94	2.0	6.0	<0.50	1.7	0.81	2.4	<0.50	<0.05
	Max	<2.0	4.3	3.9	1.1	8.5	9.2	0.51	3.8	1.2	4.8	11	0.77	1.9	0.94	4.7	<0.50	<0.05
DEP (µg/kg)	Mean	42	0	24	0	16	102	0	18	11	17	80	5.3	14	9.3	33	0	0
	Min	<30	<35	14	<10	<15	65	<5	<15	8.6	<10	48	<7.5	12	<10	23	<7.5	<0.50
	Median	<30	<35	27	<10	18	87	<5	20	9.3	14	74	<7.5	14	11	37	<7.5	<0.50
	Max	95	<35	30	<10	22	154	<5	27	15	30	118	8.5	15	12	40	<7.5	<0.50
DnBP (µg/kg)	Mean	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0
	Min	<100	<100	<50	<30	<50	<50	<20	<75	<20	<40	<150	<20	<40	<40	<70	<25	<1.5
	Median	<100	<100	<50	<30	<50	<50	<20	<75	<20	<40	<150	<20	<40	<40	<70	<25	<1.5
	Max	<100	<100	<50	<30	<50	60	<20	<75	<20	<40	<150	<20	<40	<40	<70	<25	<1.5
DPP (µg/kg)	Mean	0.65	0.65	0.17	0	0.82	0.22	0.03	0.62	0	0.50	0	0	0	0	0	0	0
	Min	<0.50	0.55	<0.20	<0.10	0.17	<0.20	<0.05	<0.25	<0.10	0.22	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Median	<0.50	0.59	0.20	<0.10	1.1	0.21	<0.05	0.57	<0.10	0.47	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
	Max	1.5	0.82	0.21	<0.10	1.2	0.36	0.05	1.2	<0.10	0.81	<0.50	<0.10	<0.15	<0.15	<0.25	<0.10	<0.01
BBzP (µg/kg)	Mean	1.5	2.0	0	0	1.4	1.3	0.41	3.8	0.45	1.1	3.2	0	0	1.1	0.84	0	0.06
	Min	<2.0	<2.5	<1.0	<0.75	<1.0	<1.5	<0.50	0.92	<0.50	<0.75	2.4	<0.50	<0.75	<0.75	<1.3	<0.50	<0.05
	Median	<2.0	<2.5	<1.0	<0.75	1.8	<1.5	<0.50	4.1	<0.50	0.91	3.5	<0.50	<0.75	<0.75	<1.3	<0.50	<0.05
	Max	2.5	3.4	<1.0	<0.75	1.9	2.3	0.73	6.5	0.86	1.9	3.8	<0.50	<0.75	2.5	1.3	<0.50	0.13
ATEC (µg/kg)	Mean	3.0	3.2	1.7	0.14	0.18	0.66	0	0	0	0.92	0	0.05	0.10	0	0	0	0.01
	Min	1.0	3.0	1.1	<0.10	<0.20	0.61	<0.05	<0.25	<0.10	0.51	<0.50	<0.05	<0.10	<0.15	<0.25	<0.10	<0.01
	Median	1.8	3.2	1.8	0.16	0.21	0.65	<0.05	<0.25	<0.10	0.81	<0.50	0.05	0.12	<0.15	<0.25	<0.10	<0.01
	Max	6.1	3.3	2.3	0.20	0.23	0.73	<0.05	<0.25	<0.10	1.4	<0.50	0.09	0.12	<0.15	<0.25	<0.10	0.01
DIBA (µg/kg)	Mean	0.72	0.70	0.59	0	0.35	1.2	0	0	0	0.58	1.0	0.13	0	0	0.38	0	0.01
	Min	<1.0	<0.75	0.38	<0.20	<0.35	0.64	<0.10	<0.50	<0.15	0.29	<1.0	<0.15	<0.25	<0.25	<0.50	<0.15	<0.01
	Median	<1.0	0.85	0.67	<0.20	0.38	1.4	<0.10	<0.50	<0.15	0.40	1.2	<0.15	<0.25	<0.25	<0.50	<0.15	<0.01
	Max	1.2	0.87	0.74	<0.20	0.50	1.7	<0.10	<0.50	<0.15	1.1	1.4	0.23	<0.25	<0.25	0.65	<0.15	0.01
CDPHP (µg/kg)	Mean	1.2	1.9	0.54	0.98	2.3	8.8	0.09	0.33	0.14	1.1	0	0.22	0.34	0.15	0	0	0.01
	Min	<0.75	1.6	0.36	0.66	2.0	0.83	<0.10	<0.50	<0.15	0.76	<1.0	<0.10	0.25	<0.20	<0.50	<0.15	0.01
	Median	1.0	1.6	0.63	0.86	2.1	1.4	<0.10	<0.50	0.15	0.89	<1.0	0.13	0.30	<0.20	<0.50	<0.15	0.01

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
	Max	2.1	2.3	0.64	1.4	2.7	24	0.17	0.49	0.19	1.6	<1.0	0.49	0.48	0.24	<0.50	<0.15	0.02
ATBC	Mean	180	94	39	0	140	171	0	0	0	0	164	97	0	30	98	0	6.9
(µg/kg)	Min	<150	<150	<50	<40	<60	<50	<20	<75	<25	<50	<125	<25	<40	<40	<80	<10	1.9
	Median	157	<150	<50	<40	<60	204	<20	<75	<25	<50	140	81	<40	<40	<80	<10	2.4
	Max	307	133	68	<40	359	283	<20	<75	<25	<50	289	196	<40	50	214	<10	16
DBS	Mean	0	0	0	0	17	0	0	0	0	0	46	22	0	0	42	0	0
(µg/kg)	Min	<35	<40	<15	<10	<20	<20	<5.0	<25	<7.5	<15	<50	<10	<15	<15	<25	<7.5	<0.50
	Median	<35	<40	<15	<10	<20	<20	<5.0	<25	<7.5	<15	<50	<10	<15	<15	28	<7.5	<0.50
	Max	<35	<40	<15	<10	31	<20	<5.0	<25	<7.5	<15	89	57	<15	<15	85	<7.5	<0.50
DEHA	Mean	34	0	0	0	33	29	4.8	42	0	12	45	25	0	32	48	3.8	1.2
(µg/kg)	Min	<40	<50	<20	<15	<20	<25	<7.0	<25	<10	<15	<60	<10	<15	<15	<30	<5.0	0.74
	Median	<40	<50	<20	<15	<20	<25	<7.0	42	<10	<15	<60	<10	<15	<15	42	<5.0	0.82
	Max	61	<50	<20	<15	79	63	7.3	71	<10	20	74	64	<15	80	88	6.4	2.0
BTHC	Mean	0	0	0	0	0	0	0	0	0	0.62	0	0	0	0	0	0	0
(µg/kg)	Min	<2.5	<2.5	<1.0	<0.75	<1.0	<1.5	<0.50	<1.5	<0.50	<0.75	<3.0	<0.50	<0.75	<0.75	<1.5	<0.50	<0.05
	Median	<2.5	<2.5	<1.0	<0.75	<1.0	<1.5	<0.50	<1.5	<0.50	<0.75	<3.0	<0.50	<0.75	<0.75	<1.5	<0.50	<0.05
	Max	<2.5	<2.5	<1.0	<0.75	<1.0	<1.5	<0.50	<1.5	<0.50	1.1	<3.0	<0.50	<0.75	<0.75	<1.5	<0.50	<0.05
THTM	Mean	0	0	0	0	0	0	0	0	0	0.24	0	0	0	0	0	0	0
(µg/kg)	Min	<0.75	<0.75	<0.50	<0.20	<0.50	<0.50	<0.10	<0.50	<0.20	<0.25	<1.0	<0.20	<0.50	<0.50	<0.50	<0.20	<0.01
	Median	<0.75	<0.75	<0.50	<0.20	<0.50	<0.50	<0.10	<0.50	<0.20	<0.25	<1.0	<0.20	<0.50	<0.50	<0.50	<0.20	<0.01
	Max	<0.75	<0.75	<0.50	<0.20	<0.50	<0.50	<0.10	<0.50	<0.20	0.48	<1.0	<0.20	<0.50	<0.50	<0.50	<0.20	<0.01
TOTM	Mean	0	0	0	0	0	0	0	2.0	0	2.3	0	0	1.1	0	0	0	0
(µg/kg)	Min	<5.0	<5.0	<2.5	<2.0	<2.5	<3.0	<1.0	<3.5	<1.0	<2.0	<7.5	<1.0	<1.5	<2.0	<3.5	<1.0	<0.10
	Median	<5.0	<5.0	<2.5	<2.0	<2.5	<3.0	<1.0	<3.5	<1.0	<2.0	<7.5	<1.0	<1.5	<2.0	<3.5	<1.0	<0.10
	Max	<5.0	<5.0	<2.5	<2.0	<2.5	<3.0	<1.0	2.5	<1.0	5.0	<7.5	<1.0	1.7	<2.0	<3.5	<1.0	<0.10
DiBP	Mean	0	35	16	0	15	30	0	13	0	0	48	2.5	4.7	5.0	14	0	0.20
(µg/kg)	Min	<20	<25	10	<7.5	14	26	<5.0	<10	<4.0	<7.5	<25	<3.5	<7.0	<7.0	<15	<5.0	<0.25
	Median	<20	<25	11	<7.5	16	28	<5.0	13	<4.0	<7.5	62	<3.5	<7.0	<7.0	17	<5.0	<0.25
	Max	<20	79	25	<7.5	17	35	<5.0	21	<4.0	<7.5	71	3.9	7.0	8.1	18	<5.0	0.34
DINP	Mean	0	0	0	0	120	0	14	265	0	40	0	0	0	0	0	0	0
(µg/kg)	Min	<175	<175	<75	<50	<100	<90	<20	<150	<30	<60	<225	<30	<60	<60	<100	<25	<2.5
	Median	<175	<175	<75	<50	109	<90	<20	356	<30	<60	<225	<30	<60	<60	<100	<25	<2.5
	Max	<175	<175	<75	<50	203	<90	22	364	<30	61	<225	<30	<60	<60	<100	<25	<2.5
DINCH	Mean	26	7.2	0	2.2	0	0	0	0	0	0	0	3.7	0	0	0	0	0.17

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea
	Min	20	<10	<5.0	<2.5	<5.0	<5.0	<1.5	<7.0	<1.8	<3.0	<13	<2.0	<3.5	<3.0	<6.0	<1.8	<0.15
	Median	21	<10	<5.0	<2.5	<5.0	<5.0	<1.5	<7.0	<1.8	<3.0	<13	<2.0	<3.5	<3.0	<6.0	<1.8	0.18
	Max	37	12	<5.0	4.2	<5.0	<5.0	<1.5	<7.0	<1.8	<3.0	<13	9.1	<3.5	<3.0	<6.0	<1.8	0.27
DIDP	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(µg/kg)	Min	<30	<30	<12	<8.0	<15	<15	<5.0	<20	<5.0	<10	<40	<5.0	<10	<10	<20	<6.0	<0.40
	Median	<30	<30	<12	<8.0	<15	<15	<5.0	<20	<5.0	<10	<40	<5.0	<10	<10	<20	<6.0	<0.40
	Max	<30	<30	<12	<8.0	<15	<15	<5.0	<20	<5.0	<10	<40	<5.0	<10	<10	<20	<6.0	<0.40
DEHP	Mean	0	0	0	0	0	0	0	316	0	0	0	0	0	0	0	0	0
(µg/kg)	Min	<300	<400	<150	<100	<200	<200	<50	198	<75	<150	<500	<75	<150	<150	<250	<75	<5.0
	Median	<300	<400	<150	<100	<200	<200	<50	306	<75	<150	<500	<75	<150	<150	<250	<75	<5.0
	Max	<300	<400	<150	<100	<200	<200	<50	443	<75	<150	<500	<75	<150	<150	<250	<75	<5.0
DEHT	Mean	0	0	0	0	0	0	0	187	0	0	0	0	0	0	0	0	0
(µg/kg)	Min	<150	<200	<75	<50	<100	<100	<25	<75	<35	<75	<250	<25	<75	<75	<150	<35	<2.5
	Median	<150	<200	<75	<50	<100	<100	<25	75	<35	<75	<250	<25	<75	<75	<150	<35	<2.5
	Max	<150	<200	<75	<50	<100	<100	<25	448	<35	<75	<250	<25	<75	<75	<150	<35	<2.5
Sum[1] of	Mean	238	86	68	3.5	298	354	11	802	12	51	331	140	19	55	201	2.1	8.4
plasticizers	Min	35	11	27	1.7	21	124	0.46	684	9.4	4.0	191	90	14	2.5	101	0	3.0
LB	Median	273	14	63	2.6	326	465	7.8	755	10	39	308	135	19	70	146	0	3.7
(µg/kg)	Max	408	232	113	6.1	549	473	24	968	17	109	494	197	23	93	355	6.4	19
Sum[2] of	Mean	288	148	85	4.3	351	388	20	850	12	79	394	156	21	78	240	3.8	8.6
plasticizers	Min	145	104	53	3.0	129	188	14	722	9.6	48	261	106	18	39	154	2.5	3.2
HB	Median	295	107	88	3.8	366	479	18	858	11	71	371	148	22	78	202	2.5	3.7
(µg/kg)	Max	424	234	113	6.1	559	498	27	970	17	117	549	213	24	117	363	6.4	19

< indicates a value below limit of quantification (LOQ). A hybrid bound approach was used when the means were calculated, i.e. concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero). Abbreviations of plasticizers are referred to Table 37.

[1] Sum of all plasticizers using lower bound (LB, <LOQ=0).

[2] Sum of all plasticizers using hybrid bound (medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean.

8.12.2 Exposure estimations

The estimated mean per capita intakes in the Swedish population ranged from 0 to 103 µg/person/day for the different plasticizers. The plasticizers with detection frequency >50% (DMP, DEP, and CDPHP), ATBC and the sum of all plasticizers are presented in Table 39. Because many plasticizers had concentrations below LOQ, per capita intake of ∑plasticizers was calculated using LB and HB approaches only (not UB). ATBC, using HB values, had the highest mean per capita intake (104 µg/person/day), which contributed by 40% to the total intake of plasticizers, followed by DEHA, DEP, and DINP (31, 29, and 25 µg/person/day, respectively). The proportional contributions of different plasticizers to the mean per capita intake are presented in Figure 36. The estimated mean per capita intake for ∑plasticizer was 262 µg/person/day and 3.7 µg/kg bw/day. The mean proportional contribution of each food group to the per capita intakes are presented for DMP, DEP, CDPHP, ATBC and ∑plasticizers in Figure 37. Cereal products and fatty dairy products contributed the most to the intake of ∑plasticizers (25 and 23%, respectively), followed by vegetables, fats/oils, sugar/sweets and meat. For DMP, DEP, and CDPHP the contribution from different food groups varied and no clear trend was found. For ATBC cereal products (39%) and vegetables (23%) contributed the most to the total intake.

DEHP and DEHT had low detection frequencies and high detection limits, with measurable levels only in fatty dairy products (all three or two out of three, respectively). This contributed to a significant portion of ∑plasticizers from this food group (59% of the total concentration, Table 38) and in the intake calculation for DEHP and DEHT accounted together for 13% of the total contribution of ∑plasticizers. On the other hand, the three plasticizers with the highest detection frequencies (DMP, DEP, and CDPHP) had lower levels and together contributed only to 12% (0.9, 11, and 0.3%, respectively) of the total intake from plasticizers.

Table 39. Mean daily per capita intake of plasticizers (µg/person/day) from different food groups and total intake in the Market Basket 2022 (N=3 per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)				
			DMP	DEP	CDPHP	ATBC	∑Plasticizers[1]
		LB	0	7.1	0.23	35	54
Cereal products	226	HB	0	9.4	0.26	41	65
		UB	0.45	12	0.29	46	
		LB		0		2.4	4.7
Pastries	55	HB	0.19	0	0.10	5.2	8.2
		UB		1.9		7.9	
		LB	0.48			4.4	13
Meat	194	HB	0.52	4.6	0.10	7.6	16
		UB	0.55			11	
		LB		0		0	0.05
Lean fish	15	HB	0.01	0	0.01	0	0.06
		UB		0.15		0.60	
		LB		0.24		2.2	5.4
Fatty fish	18	HB	0.09	0.28	0.04	2.5	6.3
		UB		0.33		2.9	
		LB				0.49	1.1
Meat substitutes	3	HB	0.02	0.31	0.03	0.51	1.2
		UB				0.54	
		LB		0	0.01	0	2.6
Lean dairy products	248	HB	0.11	0	0.02	0	4.9
		UB		1.2	0.03	5.0	
		LB	0.17	1.1	0.01	0	56
Fatty dairy products	70	HB	0.19	1.3	0.02	0	59
		UB	0.21	1.4	0.03	5.3	
		LB			0.001	0	0.16
Plant-based drinks	13	HB	0.01	0.14	0.002	0	0.16
		UB			0.002	0.33	
		LB		0.43		0	1.5
Eggs	29	HB	0.08	0.48	0.03	0	2.3
		UB		0.53		1.5	
		LB	0.31		0	7.9	18
Fats and oils	55	HB	0.34	4.4	0	9.0	22
		UB	0.36		0.06	10	
		LB	0.06	0.69	0.05	23	34
Vegetables	245	HB	0.10	1.3	0.05	24	38
		UB	0.14	1.9	0.06	25	
		LB				0	4.0
Fruits	215	HB	0.37	2.9	0.07	0	4.6
		UB				8.6	
		LB	0.08	1.1	0.01	2.4	7.8
Potatoes	142	HB	0.10	1.3	0.02	4.3	11
		UB	0.12	1.6	0.03	6.2	
		LB			0	5.3	15
Sugar and sweets	74	HB	0.22	2.5	0	7.3	18
		UB			0.04	9.2	

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)				
			DMP	DEP	CDPHP	ATBC	∑Plasticizers[1]
Beverages	262	LB	0	0	0	0	0.56
		HB	0	0	0	0	1.0
		UB	0.13	2.0	0.04	2.6	
Coffee and tea	407	LB	0	0			3.4
		HB	0	0	0.006	2.8	3.5
		UB	0.02	0.20			
Total		**LB**	**2.2**	**26**	**0.72**	**85**	**222**
		HB	**2.4**	**29**	**0.78**	**104**	**262**
		UB	**3.1**	**38**	**0.98**	**145**	
µg/kg bw/day		**HB**	**0.03**	**0.41**	**0.01**	**1.5**	**3.7**

Abbreviations of plasticizers are referred to Table 37. LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

[1] Because many plasticizers had concentrations below LOQ, per capita intake of ∑plasticizers was calculated using LB and HB approaches only (not UB).

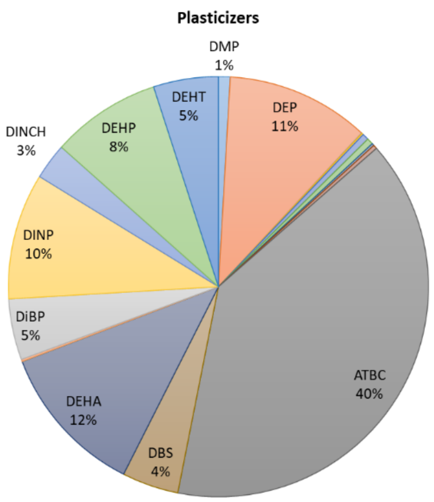

Figure 36. Percentage contribution to the per capita intake of the different plasticizers.

Substances contributing less than 0.5% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

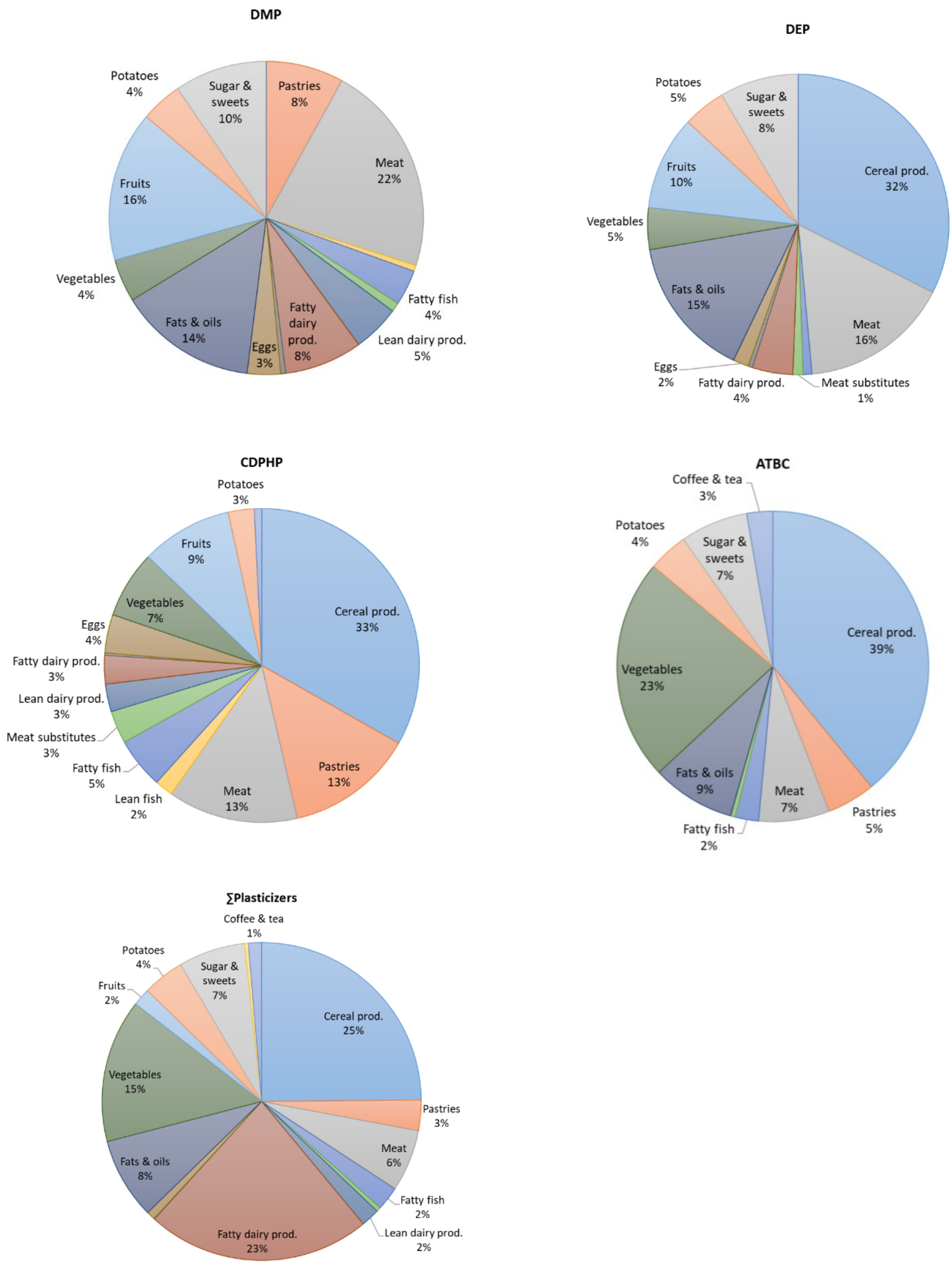

Figure 37. Percentage contribution to the per capita intake of DMP, DEP, CDPHP, ATBC and ∑plasticizers from food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of quantification, LOQ] was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

8.12.3 Risk assessment

The estimated per capita exposure was compared to established TDIs from EFSA (EFSA et al., 2019, EFSA, 2006) and calculated reference doses (NOAELs with an uncertainty factor of 1000) for plasticizers previously reported (Christia et al., 2019a). Out of the 20 plasticizers analysed in the Market Basket 2022, 6 substances have TDI values (DnBP, BBzP, DINP, DINCH, DIDP, and DEHP) and 7 have reference doses (DEP, DPP, CDPHP, ATBC, DEHA, TOTM, and DEHT) that could be compared to the estimated per capita intakes. The TDIs ranged between 10 and 1000 µg/kg bw/day, depending on the plasticizer, and the reported reference doses ranged between 4 and 225 µg/kg bw/day. These could be compared to the estimated per capita intakes of the 13 plasticizers ranging from 0 to 1.5 µg/kg bw/day. The lowest margins were observed for DEHT where the intake was 21 times lower compared to the reference dose. However, DEHT had a low detection frequency (4%) and was only detected in fatty dairy products, which makes the results uncertain. The per capita intakes for the other plasticizers were 140-47,000 times lower compared to the reference doses showing that the Swedish population is likely not at risk for adverse effects of plasticizers through dietary exposure. There are also other exposure ways for plasticizers, such as dust, air and use of personal care products and it is possible that the total daily exposure would increase if these exposure routes were included as well.

8.12.4 Conclusion

In total, 20 plasticizers were analysed in the Market Basket 2022 with a detection frequency of 0-71%. DMP, DEP, and CDPHP had the highest detection frequency and the highest levels of ∑plasticizers were found in fatty dairy products followed by meat substitutes, fats/oils, fatty fish, and cereal products. The mean per capita intakes were ranging from 0 to 103 µg/day and the total intake of all plasticizers was 262 µg/day. ATBC had the highest mean per capita intake and contributed by 40% to the total intake of plasticizers, followed by DEHA, DEP, and DINP. Cereal products and fatty dairy products contributed the most to the total intake of ∑plasticizers. The risk assessment showed a large margin between the estimated per capita intakes and the reference doses.

8.13 Acrylamide

Acrylamide is an industrial chemical used to produce polyacrylamide, that is used as flocculants in wastewater treatment plants. Acrylamide is also used in the production of monomers used for grouting in e.g. tunnel constructions (IARC, 1994). Exposure of acrylamide from food was discovered in 2002, when experiments showed that acrylamide is formed in common carbohydrate-rich foods (Tareke et al., 2002). The formation occurs at temperatures above 120 °C through a Maillard reaction where reduced sugars react with the amino acid asparagine. The reaction is favoured at low water content, a condition that occurs during frying, baking and roasting of e.g., potatoes (French fries, crisps) and bread. Acrylamide is classified as a probable carcinogen, group 2A (IARC, 1994), and it may also cause other toxic effects, i.e. neurotoxicity (EFSA, 2015a). It is metabolised in vivo to glycidamide, a genotoxic and mutagenic chemical in animal studies. The exposure to this type of substances should be as low as possible. There are no maximum levels for acrylamide within EU, but there are indicative values of acrylamide for several food products, as guidance for the food producers to keep the levels down (Regulation (EU) 2017/2158).

This is the first time that acrylamide has been analysed in a market basket study. It was analysed in eight food groups considered relevant for acrylamide occurrence. The analyses were performed at the Swedish Food Agency, and the analytical method is described in Appendix 4 (section A 4.11). Briefly, acrylamide is extracted from the mixed food items using water, and further cleaned-up using solid phase extraction. The analysis is performed by LC-MS/MS. The LOQ was determined to 5 µg/kg. The method has been developed by the Swedish Food Agency and is approved as a ”standard method” by the European Committee for Standardization (CEN).

8.13.1 Concentrations in food groups

In total, acrylamide was analysed in eight food groups. The results are summarized in Table 40. Because the food items were analysed as is (not cooked, except for coffee/tea) and the food group potatoes is a mixture of potatoes, Frensh fries and crips, the measured mean concentration in the analysed potato group (25 µg/kg) is lower compared to in ready to consume (fried/roasted) potato products. As a comparison, the measured concentration in French fries/fried potatoes is about 10 times higher in another study performed at the Swedish Food Agency during 2022 (data used by (Vryonidis et al., 2024)). The reported mean value of acrylamide in French fries/fried potatoes in the EFSA opinion regarding acrylamide is 290 µg/kg from 1598 measurements (EFSA, 2015a).

Table 40. Concentrations of acrylamide (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	*Pizza, hand pie*	Meat substitutes[1]	Potatoes[2]	Sugar and sweets	Beverages	Coffee and tea
Acrylamide	Mean	14	48	0	8.3	25	21	0	8.9
(µg/kg)	Min	10	41	<5.0	<5.0	21	14	<5.0	7.4
	Median	13	45	<5.0	<5.0	25	24	<5.0	9.4
	Max	19	58	<5.0	20	31	27	<5.0	9.9

Acrylamide was not analysed in the following food groups: meat, processed meat, lean or fatty fish, lean or fatty dairy products, plant-based drinks, eggs, fats/oils, vegetables and fruits.
< indicates a value below limit of quantification (LOQ). A hybrid bound approach was used when the means were calculated, i.e. concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero).
[1] Acrylamide was only detected in one sample.
[2] The analyses were performed on potato products where raw (uncooked) potatoes was included, and therefore the measured concentrations are likely lower compared to in consumed (cooked) potato products.

8.13.2 Exposure estimations

The estimated mean intakes of acrylamide in the Swedish population (per capita intakes) are presented in Table 41, and the contribution of each food group to the per capita intake of acrylamide is presented in Figure 38. The mean estimated total intake of acrylamide (HB) was calculated to be 14.7 µg/day.

Most samples had concentrations of acrylamide above LOQ (Table 41). The total per capita intake of acrylamide varied about 10% between the market baskets from the three grocery chains.

Potatoes contributed with 25% to the total estimated intake of acrylamide. However, as no cooking was performed prior to analysis, this number is likely underestimated. Coffee and tea also contributed with 25% and cereal products with 22% to the total intake. The pastries and sugar and sweets group contributed with 18% and 11%, respectively, whereas meat substitutes contributed least with 0.2%, and the food group beverages did not contribute at all (Figure 38).

Table 41. Mean daily intake of acrylamide (µg/day) from different food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/day)		Per capita intake (µg/day)
Cereal products	226		3.2
Pastries	55		2.6
Pizza, hand pie[1]	11	LB	0
		HB	0
		UB	0.055
Meat substitutes	3	LB	0.020
		HB	0.025
		UB	0.030
Potatoes	142		3.6[2]
Sugar and sweets	74		1.6
Beverages	262	LB	0
		HB	0
		UB	1.3
Coffee and tea	407		3.6
Total		**LB**	**15**
		HB	**15**
		UB	**16**

Acrylamide was not analysed in the following food groups: meat, processed meat, lean or fatty fish, lean or fatty dairy products, plant-based drinks, eggs, fats/oils, vegetables and fruits.

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

[1] Pizza/hand pie is a subgroup of pastries and its consumption is included in pastries. The subgroup was therefore not included when calculating total per capita intake.

[2] Likely underestimated as no preparation (cooking) of the raw potato products was performed prior to analysis.

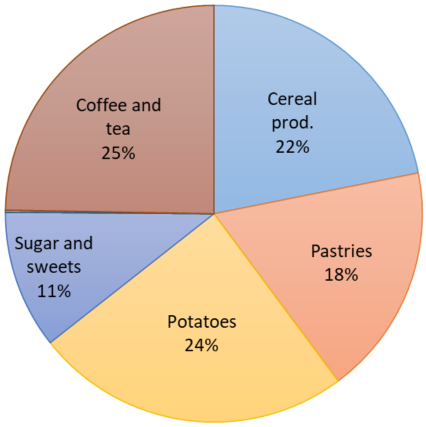

Figure 38. Percentage contribution to the per capita intake of acrylamide from food groups in the Market Basket 2022.

The contribution from the potato group is likely underestimated as no preparation (cooking) of the raw potato products was performed prior to analysis. Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentages are based on mean per capita intake per food group. When calculating the mean, hybrid bound (HB) concentrations (0.5*LOQ) were imputed for concentrations below LOQ. If the concentration was below LOQ for all three samples within a food group HB was set to zero.

8.13.3 Risk assessment

In the risk assessment performed by EFSA 2015, a reference point (BMDL10) of 0.17 mg/kg bw/day was derived from data on the Harderian gland adenomas and adenocarcinomas in male B6C3F1 mice exposed to acrylamide for two years (EFSA, 2015a). As both acrylamide and its metabolite glycidamide are genotoxic it is not possible to establish a TDI of acrylamide. Instead, the MOE approach is used for this type of substances. The MOE describes the difference (ratio) between the dose giving the critical effect and the exposure dose (intake). A MOE of 10 000 or larger is considered as low concern to public health.

The estimated mean total intake of acrylamide (HB) in the Market Basket 2022 was 15 µg/day, or 0.21 µg/kg bw/day assuming a body weight of 70 kg. This value is less than half compared to the total intake for adults estimated by EFSA, 0.5 µg/kg/day (EFSA, 2015a). One probable explanation to this difference is the underestimation of the acrylamide levels in the potato food group in the present study. Still, the calculated MOE of 808 from data in the present study indicates concern for health effects.

8.13.4 Conclusion

The highest concentrations of acrylamide were detected in pastries, followed by potatoes and sugar and sweets. The concentrations in cereal products were also relatively high. These food groups, together with coffee and tea contributed most to the total intake of acrylamide. The total intake is much lower compared to the estimated total intake reported by EFSA. This is likely due to underestimation of the levels of acrylamide in the potato group, due to “dilution” of raw (not prepared, i.e., fried/roasted) potatoes in the food group. Still, the margin of exposure indicates concern for public health from acrylamide intake.

8.14 Glycidol, 2-MCPD and 3-MCPD

Fatty acid esters of glycidol and 2-monochloropropane-1,3-diol (2-MCPD) and 3-monochloropropane-1,2-diol (3-MCPD) are food processing contaminants which are formed in the deodorization step of vegetable edible oils during processing. The highest levels have been found in refined palm oils (Cheng et al., 2017, EFSA, 2016c). As oils are used in a variety of food products there are many sources for exposure. When ingested, the ester bonds are hydrolysed in the gastrointestinal tract releasing "free" glycidol and MCPDs. Free 2-MCPD and 3-MCPD can also be formed in hydrolyzed vegetable protein (HVP), which is used during the production of e.g., broths.

Glycidol is classified as a probable carcinogen, group 2A (IARC, 2000) and 3-MCPD as a possible carcinogen, group 2B (IARC, 2013). 3-MCPD is also toxic to the kidneys, as shown in animal experiments, with an estimated tolerable intake of 2 µg/kg/day (EFSA, 2018b). Due to limited data availability, there has not been possible to derive a health-based guidance value for 2-MCPD (EFSA, 2016c).

There are maximum levels in the EU legislation for fatty acids of glycidol and 3-MCPD in some food products, mainly intended for infants, but also for vegetable fats and oils (Commission regulation (EU) 2023/915). For 2-MCPD, there are maximum levels for soy sauces and HVP.

In the present study, glycidol, 2-MCPD and 3-MCPD and their fatty acid esters was analysed in ten food groups using GC/MS. The analyses were performed at the accredited laboratory SGS Analytics (Hamburg, Germany), described in Appendix 4 (section A 4.12). The LOQs were 5 µg/kg for free 2-MCPD and 3-MCPD, and 10 µg/kg for MCPD fatty acid esters and glycidyl esters in fats and other food items.

8.14.1 Concentrations in food groups

Glycidyl esters (hereafter glycidol), free and bound (as esters) 2-MCPD and 3-MCPD were analysed in ten food groups. In general, the levels of the compounds were low in most samples. Glycidol was only detected in three food groups (pastries, meat substitutes and fats and oils). The sum of bound and free 3-MCPD were detected in seven of the food groups (cereals, pastries, lean fish, meat substitutes, fats and oils, potatoes and sugar and sweets). The sum of bound and free 2-MCPD were detected in four food groups (pastries, fats and oils, lean fish and meat substitutes). The concentrations are presented in Appendix A 5.4 and summarized for glycidol and the sum of bound and free 2-MCPD and 3-MCPD in Table 42.

Table 42. Concentrations of glycidol and the sum of bound and free 2-MCPD and 3-MCPD esters (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Plant-based drinks	Fats and oils	Potatoes	Sugar and sweets
Glycidol (µg/kg)	Mean	0	22	0	0	0	9.3	0	63	0	0
	Min	<10	18	<10	<10	<10	5.0[1]	<10	51	<10	<10
	Median	<10	22	<10	<10	<10	11	<10	60	<10	<10
	Max	<10	26	<10	<10	<10	12	<10	79	<10	<10
Total 2-MCPD (µg/kg)	Mean	0	32	0	20[1]	0	22	0	48	0	0
	Min	<LOQ	27	<LOQ	7.5	<LOQ	17	<LOQ	38	<LOQ	<LOQ
	Median	<LOQ	28	<LOQ	21	<LOQ	19	<LOQ	43	<LOQ	<LOQ
	Max	<LOQ	43	<LOQ	30	<LOQ	30	<LOQ	65	<LOQ	<LOQ
Total 3-MCPD (µg/kg)	Mean	11	71	0	34	0	52	0	112	13	17
	Min	10	56	<LOQ	10[1]	<LOQ	43	<LOQ	94	7.5	14
	Median	11	64	<LOQ	34	<LOQ	47	<LOQ	97	10	18
	Max	11	93	<LOQ	56	<LOQ	68	<LOQ	147	20	19

Concentrations were not analysed in the following food groups: pizza/hand pie, meat, lean or fatty dairy products, eggs, vegetables, fruits, beverages and coffee/tea.

< indicates a value below limit of quantification (LOQ). Mean, min, median and max are given for the hybrid bound approach, i.e. concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero).

[1] Detected in two of three samples.

8.14.2 Exposure estimations and time trends

Estimated mean intakes of glycidol and MCPD esters in the Swedish population (per capita intakes) are presented in Table 43. The contribution of each food group to the per capita intakes of glycidol and the total 2-MCPD and 3-MCPD are presented in Figure 39. Only a few food groups contributed to the estimated total intakes, with mean (HB) intakes of 4.7 µg/day for glycidol and 14 µg/day for 3-MCPD. The estimated total per capita intakes of glycidol, total 2-MCPD and total 3-MCPD varied about 30% between the market baskets from the three grocery chains.

The food group fats and oils contributed most to the total intake for both glycidol (74%), 2-MCPD (56%) and 3-MCPD (43%) followed by pastries, likely due to a high fat content (Figure 39). For 3-MCPD, several additional food groups contributed to the total exposure, i.e., cereal products (9%), potatoes (8%) and sugar and sweets (7%). Also, lean fish contributed to the total intake, likely due to the presence of fish sticks in the pooled food group.

Table 43. Mean daily intake of glycidol, 2- and 3-MCPD (µg/day) from different food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/day)		Per capita intake (µg/day)		
			Glycidol	2-MCPD	3-MCPD
Cereal products	226	LB	0	0	1.3
		HB	0	0	1.3
		UB	2.3	3.4	3.5
Pastries	55	LB		1.6	3.8
		HB	1.2	1.6	3.9
		UB		1.9	4.0
Processed meat	48	LB	0	0	0
		HB	0	0	0
		UB	0.48	0.72	0.72
Lean fish	15	LB	0	0.23	0.48
		HB	0	0.29	0.50
		UB	0.15	0.36	0.53
Fatty fish	18	LB	0	0	0
		HB	0	0	0
		UB	0.18	0.27	0.27
Meat Substitutes[1]	3	LB	0.02	0.06	0.15
		HB	0.03	0.06	0.16
		UB	0.03	0.07	0.16
Plant-based Drinks	13	LB	0	0	0
		HB	0	0	0
		UB	0.13	0.20	0.20
Fats and oils	55	LB		2.5	6.0
		HB	3.5	2.5	6.0
		UB		2.8	6.3
Potatoes	142	LB	0	0	0.96
		HB	0	0	1.1
		UB	1.4	2.1	2.6
Sugar and Sweets	74	LB	0	0	1.0
		HB	0	0	1.0
		UB	0.74	1.1	1.4
Total		**LB**	**4.7**	**4.4**	**14**
		HB	**4.7**	**4.5**	**14**
		UB	**10**	**13**	**20**

Concentrations were not analysed in the following food groups: pizza/hand pie, meat, lean or fatty dairy products, eggs, vegetables, fruits, beverages and coffee/tea.

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects).

[1] Processed meat is a subgroup of meat and its consumption is included in meat. The subgroup was therefore not included when calculating total per capita intake.

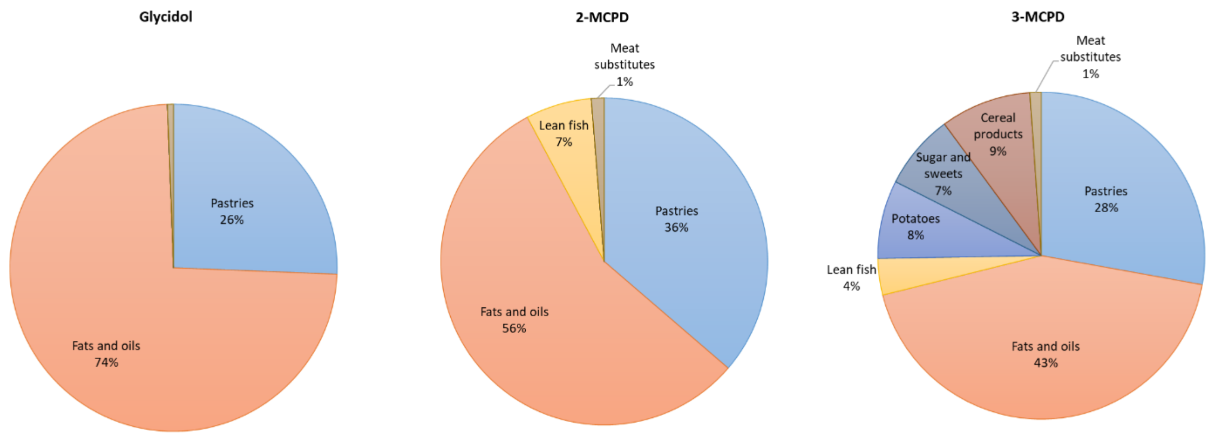

Figure 39. Percentage contribution to the per capita intake of glycidol, 2-MCPD and 3-MCPD, respectively, from food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentages are based on mean per capita intake per food group. When calculating the mean, hybrid bound (HB) concentrations (0.5*LOQ) were imputed for concentrations below LOQ. If the concentration was below LOQ for all three samples within a food group HB was set to zero.

Glycidol and MCPD esters have been included in one earlier market basket study at the Swedish Food Agency, the Market Basket 2015 (Swedish Food Agency, 2017). The same food groups were analysed in both studies, except for the addition of the food groups fats and oils, plant-based drinks and meat substitutes in the present study. In the present study, the fats and oils group contributed most to the total intake, whereas there was only a minor contribution from plant-based drinks and meat substitutes. In the previous study, the pastries contributed most to the total intake, but fats or oils were not analysed at that time. The total calculated per capita intake of glycidol was lower in the present study (4.7 µg/day) compared to in the Market Basket 2015 (7.6 µg/day) despite the contribution from the fats and oil group, which was not included previously. A likely explanation to the difference is the lower detected levels of glycidol in the present study. The concentration of glycidol was about three times lower in the pastries group and <LOQ in the sugar and sweets group in the present study compared to the Market Basket 2015. For 3-MCPD the estimated per capita intake was 26 µg/day in 2015 compared to 13.9 µg/day in the present study. This difference can also be explained by lower detected levels in the present study.

8.14.3 Risk assessment

EFSA has performed a risk assessment of glycidol, where they derived a reference point, T25, which represents the dose corresponding to a 25% incidence of tumours. The T25 of 10.2 mg/kg bw/day was derived from data on neoplastic effects in long-term exposed male rats (EFSA, 2016c). As glycidol is genotoxic and carcinogenic it is not possible to establish a TDI. Instead, the MOE approach is used. Using T25 as a reference point, a MOE of 25 000 or larger is considered as low health concern.

The estimated mean total intake of glycidol (HB) in the Market Basket 2022 was 4.7 µg/day, or 0.07 µg/kg bw/day assuming a body weight of 70 kg. The calculated MOE is 151 228, indicating no concern for health effects.

EFSA has also performed a risk assessment of 3-MCPD, with a derived $BMDL_{10}$ of 0.20 mg/kg/day, based on renal effects in male rats, and the corresponding TDI of 2 µg/kg/day using an uncertainty factor of 100 (EFSA, 2018b). The estimated daily intake from the Market Basket 2022 was 0.2 µg/kg per day, assuming a body weight of 70 kg, and thus well below the TDI.

8.14.4 Conclusion

The highest concentrations of glycidol, and total (bound and free) 2-MCPD and 3-MCPD were detected in fats and oils, followed by pastries. These food groups also contributed most to the total intake of glycidol and the MCPD. Based on the mean intakes of both glycidol and 3-MCPD there is low concern for health effects in the public.

8.15 Polycyclic aromatic hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are a large group of chemicals that are formed mainly during incomplete combustion (EFSA, 2008a). Cigarette smoking is a significant source for exposure, while for non-smokers, consumption of food is a major source.

In 2002 the Scientific Committee on Food (SCF) together with the Joint FAO/WHO Expert Committee on Food Additives (JECFA) concluded that 15 different PAHs showed clear evidence of carcinogenic effects in experimental animals (referring to EFSA (EFSA, 2008a)). One of the compounds was benzo(a)pyrene, which is classified as a human carcinogen, group 1 (IARC, 2010), which SCF suggested could be used as a biomarker of occurrence and effects of carcinogenic PAHs in food. In 2008, EFSA evaluated these 15 suggested PAHs, with special attention on those PAHs that were measured in the coal tar mixtures used in carcinogenicity studies. They concluded that the sum of benzo(a)pyrene, chrysene, benz(a)anthracene and benzo(b)fluoranthene (PAH4) or the sum of benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, chrysene, dibenz(a,h)anthracene and indeno(1,2,3-cd)pyrene (PAH8) are better indicators of occurrence than benzo(a)pyrene alone (EFSA, 2008a).

In EU regulation (Commission regulation (EU) 2023/915), maximum limits in several dried and smoked food products are stated for benzo(a)pyrene and the sum of benzo(a)pyrene, chrysene, benz(a)anthracene and benzo(b)fluoranthene (PAH4).

In this study, benzo(a)pyrene, chrysene, benz(a)anthracene and benzo(b)fluoranthene have been analysed in 13 food groups. The analyses were performed at the laboratory at the Swedish Food Agency using a GC-MS method described in Appendix 4 (section A 4.13). Briefly, samples from the food groups were spiked with internal standard prior to sample work-up and clean-up. Thereafter, samples were analysed using gas chromatography and mass spectrometry. The LOD was calculated to 0.03 µg/kg.

8.15.1 Concentrations in food groups

All analysed PAHs, i.e., benzo(a)pyrene, chrysene, benz(a)anthracene and benzo(b)-fluoranthene, were detected in all food groups, except benzo(a)pyrene which was not detected in the plant-based drinks or coffee and tea. The summary of the concentrations is presented in Table 44.

Table 44. Concentrations of benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene and the sum of all four, PAH4 (fresh-weight basis) in food groups in the Market Basket 2022 (N=3 samples per food group). Concentrations were not analysed in the following food groups: pizza/hand pie, lean or fatty dairy products, eggs, potatoes and beverages.

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish[1]	Fatty fish[2]	Meat substitutes	Plant-based drinks	Fats and oils	Vegetables	Fruits[3]	Sugar and sweets	Beverages
Benz(a)anthracene	Mean	0.07	0.11	0.08	0.06	0.03	0.08	0.09	0.06	0.20	0.06	0.06	0.12	0.05
	Min	0.06	0.10	0.06	0.04	<0.03	0.07	0.04	0.05	0.18	0.06	0.06	0.10	0.05
(µg/kg)	Median	0.07	0.11	0.06	0.07	0.03	0.08	0.08	0.05	0.19	0.06	0.06	0.12	0.05
	Max	0.07	0.12	0.12	0.08	0.03	0.09	0.14	0.07	0.22	0.07	0.06	0.13	0.05
Chrysene	Mean	0.12	0.18	0.13	0.11	0.07	0.13	0.12	0.10	0.33	0.11	0.11	0.18	0.09
	Min	0.12	0.17	0.11	0.06	<0.03	0.12	0.05	0.09	0.32	0.10	0.10	0.16	0.09
(µg/kg)	Median	0.12	0.17	0.12	0.13	0.08	0.13	0.09	0.10	0.32	0.11	0.11	0.18	0.09
	Max	0.12	0.19	0.15	0.14	0.11	0.14	0.21	0.12	0.36	0.12	0.12	0.21	0.09
Benzo(b)fluoranthene	Mean	0.08	0.10	0.09	0.07	0.05	0.08	0.09	0.07	0.23	0.07	0.07	0.11	0.06
	Min	0.07	0.09	0.07	0.04	<0.03	0.07	0.05	0.06	0.22	0.07	0.07	0.10	0.06
(µg/kg)	Median	0.08	0.09	0.08	0.09	0.07	0.08	0.08	0.07	0.24	0.07	0.07	0.11	0.06
	Max	0.08	0.12	0.12	0.09	0.07	0.08	0.13	0.07	0.24	0.08	0.08	0.13	0.06
Benzo(a)pyrene	Mean	0.03	0.10	0.07	0.04	0.02	0.03	0.05	0.00	0.12	0.03	0.02	0.06	0.00
	Min	0.03	0.07	0.03	0.03	<0.03	<0.03	0.03	<0.03	0.11	0.03	<0.03	0.05	<0.03
(µg/kg)	Median	0.03	0.11	0.04	0.04	<0.03	0.03	0.05	<0.03	0.11	0.03	<0.03	0.05	<0.03
	Max	0.03	0.12	0.14	0.04	0.03	0.04	0.07	<0.03	0.14	0.03	0.03	0.08	<0.03
PAH4	Mean	0.29	0.49	0.37	0.28	0.15	0.31	0.34	0.23	0.88	0.28	0.25	0.47	0.20
	Min	0.28	0.43	0.28	0.17	<0.03	0.29	0.17	0.20	0.84	0.26	0.23	0.45	0.20
(µg/kg)	Median	0.30	0.48	0.29	0.33	0.18	0.30	0.30	0.22	0.85	0.27	0.26	0.45	0.20
	Max	0.30	0.55	0.53	0.35	0.26	0.34	0.55	0.26	0.96	0.30	0.27	0.52	0.20

< indicates a value below limit of quantification (LOD). When calculating means as well as concentrations of PAH4, hybrid bound approach was used. This means that concentrations below LOQ were replaced by 0.5*LOQ, but when all three samples in a food group had concentrations below LOQ the concentrations were replaced by 0 (zero).

[1] Detected in one (benzo(a)pyrene) or two (benz(a)anthranzene, chrysene, benzo(b)fluoranthene) of three samples.

[2] Detected in two of three samples (benzo(a)pyrene).

[3] Detected in one of three samples (benzo(a)pyrene).

8.15.2 Exposure estimations and time trends

Estimated mean intakes have been calculated for benzo(a)pyrene and for PAH4 in the Swedish population (per capita intakes), presented in Table 45. The estimated total per capita intakes of benzo(a)pyrene and PAH4 varied about 30-40% and ca 10%, respectively between the market baskets from the three grocery chains. The contribution of each food group to the per capita intakes of benzo(a)pyrene and PAH4 are presented in Figure 40. The mean estimated total intake of benzo(a)pyrene and PAH4 (HB) were calculated to be 50 ng/day and 463 ng/day, respectively.

The study shows that intake of benzo(a)pyrene and PAH4 comes from many food sources. In the present study, the largest contribution of benzo(a)pyrene to the total intake came from the meat group (27%). Worth noting is that the large contribution of meat is driven by one sample of the triplicates, which was about four times higher compared to the other two samples. The food groups pastries, fats and oils, cereal products, and vegetables contributed to the intake with ca 11-15%. Sugar and sweets and fruits contributed with about 9% (Figure 40). For PAH4, the contribution from the different food groups to the total intake was almost evenly distributed, with a contribution of 11-18% for the food groups fats and oils, fruits, cereal products, coffee and tea, vegetables and meat. Sugar and sweets and pastries contributed with 8% and 6%, respectively. For none of the analytes, the food groups fish (lean and fatty), plant-based drinks or meat substitutes contributed extensively.

Table 45. Mean daily intake of benzo(a)pyrene and PAH4 (ng/day) from different food groups and total intake in the Market Basket 2022 (N=3 samples per food group).

Food group	Per capita consumption (g/day)		Per capita intake Benzo(a)pyrene (ng/day)	Per capita intake PAH4 (ng/day)
Cereal products	226		6.8	66
Pastries	55		5.5	26
Meat	194		14	71
Processed meat	*48*		*1.8*	*14*
Lean fish	15	LB	0.15	2.2
		HB	0.30	2.3
		UB	0.45	2.4
Fatty fish	18	LB	0.42	
		HB	0.51	5.6
		UB	0.60	
Meat substitutes	3		0.15	1.0
Plant-based drinks	13	LB	0	
		HB	0	3.0
		UB	0.39	
Fats and oils	55		6.6	49
Vegetables	245		7.4	68
Fruits	215	LB	2.2	
		HB	4.3	54
		UB	6.5	
Sugar and sweets	74		4.4	35
Coffee and tea	407	LB	0	
		HB	0	81
		UB	12	
Total		**LB**	**47**	
		HB	**50**	**463**
		UB	**65**	

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of quantification (LOQ) is used for non-detects, except for when all three samples in one food group have concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOQ is used for non-detects).

[1] Processed meat is a subgroup of meat and its consumption is included in meat. The subgroup was therefore not included when calculating total per capita intake.

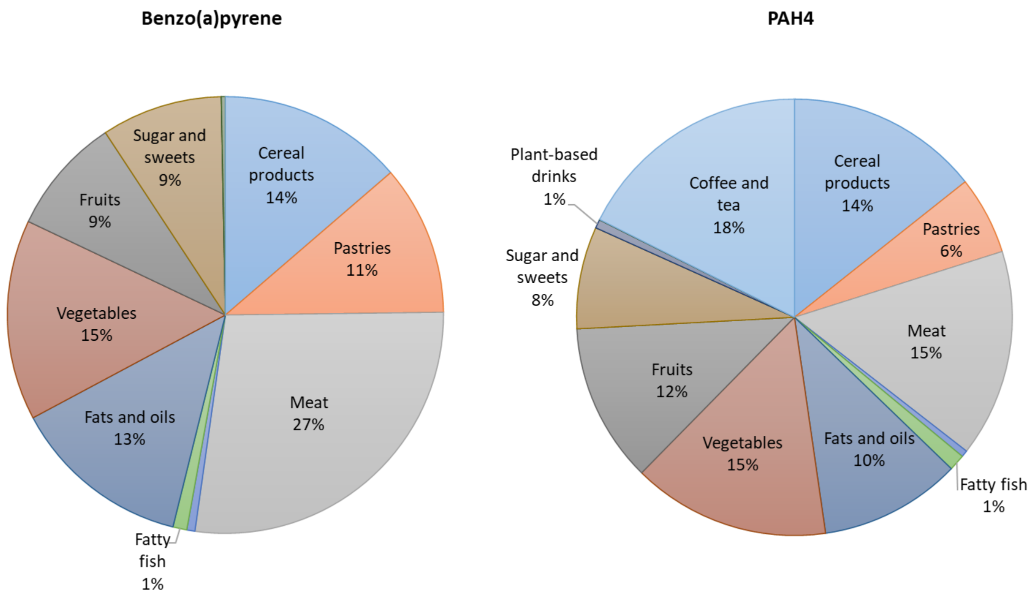

Figure 40. Percentage contribution to the per capita intake of benzo(a)pyrene and PAH4, respectively, from food groups in the Market Basket 2022. Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text.

The percentages are based on mean per capita intake per food group. When calculating the mean, hybride bound (HB) concentrations (0.5*LOQ) were imputed for concentrations below LOQ. If the concentration was below LOQ for all three samples within a food group HB was set to zero.

Between 1999-2015 (Swedish Food Agency, 2012, Swedish Food Agency, 2017) there seemed to be a decreasing trend of the per capita intakes of benzo(a)pyrene and PAH4, but in the present market basket study the per capita intakes were higher compared to the previous estimations (Figure 41). One reason could be that more food groups were included in the present study, but this does not explain the entire difference as higher intakes were obtained also when excluding these food groups. It is also important to point out that fatty dressings were included in fats and oils in the present study but in sugar and sweets in previous market basket studies (see Table 3).

In comparison to the estimated mean daily exposure for the European population, performed by EFSA, the results are approximately four times lower due to higher reported concentrations of benzo(a)pyrene and PAH4 in the EFSA summary (EFSA, 2008a). The type of processing of the food may influence the levels of PAHs, where for example hard barbequing/grilling has shown to increase the concentrations. In the present study no cooking was performed of the food, whereas in the EFSA summary grilled meat was included. However, the largest contributions to the total estimated intake performed by EFSA came from cereal products and seafoods.

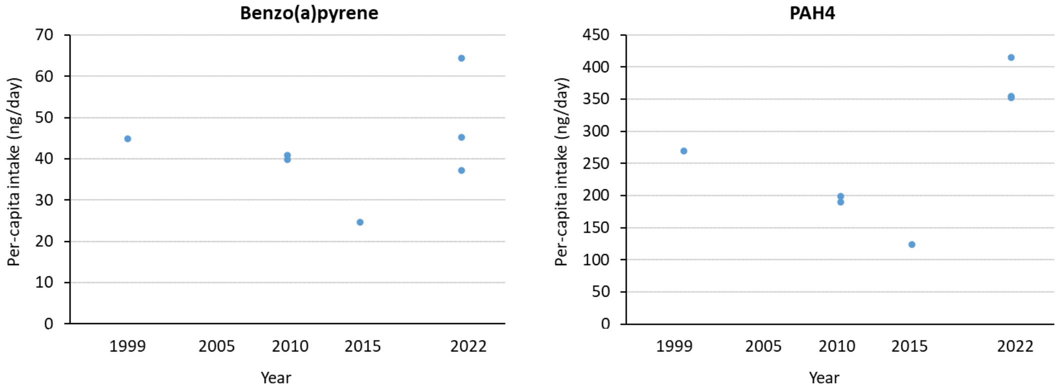

Figure 41. Temporal trends of per capita intakes of benzo(a)pyrene and PAH4, estimated in market basket studies in Sweden 1999-2022.
Note, that the per capita intake is a function of per capita consumption and concentrations in the food groups. Food groups included are cereal products, pastries, meat, fats and oils, vegetables, fruits, meat substitutes, plant-based drinks and sugar and sweets. The number of samples per food group were N=1 (1999; mean from four different grocery chains in Gothenburg, Malmö, Sundsvall and Uppsala; and 2015; mean from five grocery chains in Uppsala), N=2 (2010, mean from normal and low-price baskets from five grocery chains in Uppsala), N=3 (2022; three grocery chains in Uppsala).

8.15.3 Risk assessment

EFSA has derived a $BMDL_{10}$ of 0.07 mg/kg/day for benzo(a)pyrene and a $BMDL_{10}$ of 0.34 mg/kg/day for PAH4 from a two-year carcinogenicity study on coal tar mixtures in mice (EFSA, 2008a, Culp et al., 1998).

Assuming a bodyweight of 70 kg, the mean daily intakes of benzo(a)pyrene (50 ng/day) and PAH4 (463 ng/day) were calculated to be 0.71 ng/kg/day, or 6.6 ng/kg/day, respectively. The MOE approach was used, where the ratio between the dose giving the critical effect, i.e., $BMDL_{10}$ (0.07 mg/kg/day) and the exposure dose (intake) was calculated. The calculated MOEs for benzo(a)pyrene and PAH4 are 98 970 and 51 373, respectively. Thus, the intakes of these are considered a low concern for health in the general population as the MOE is higher than 10 000, which is generally set as a cut off for genotoxic and carcinogenic substances when MOE is based on a $BMLD_{10}$ as a reference point, as for benzo(a)pyrene and PAH4 (EFSA, 2005a).

8.15.4 Conclusion

The highest intakes were detected in meat for both benzo(a)pyrene and PAH4, but also other included food groups contributed substantially to the total intake of PAH4. As no cooking was performed, the levels in e.g. meat may be underestimated. For those who are high consumers of grilled meat, higher exposure levels of both benzo(a)pyrene and PAH4 would be expected. The estimated intakes were higher compared to earlier market basket studies but still the margin to the critical effect (margin of exposure, MOE) is large and thus no concern for health is considered.

8.16 Mycotoxins

Mycotoxins are secondary metabolites produced by moulds, which in small concentrations initiate a toxic response in vertebrates. They can be formed throughout the entire food chain when moulds grow on crops or ingredients, and they are typically very stable chemical substances. A few mycotoxins of great importance to health and trade (e.g. aflatoxins, ochratoxin A, deoxynivalenol and patulin) are regulated with maximum levels in food (Regulation (EU) 2023/915, 2023). However, there are many hundreds of mycotoxins described (Bräse et al., 2009).

Nine mycotoxins, or groups of mycotoxins, were analysed in two food groups, cereal products and fruits. Analysed toxins were aflatoxins (AFB1, B2, G1 and G2); ochratoxin A (OTA); deoxynivalenol (DON) and its acetylated metabolites (3-acetyl-DON and 15-acetyl-DON); zearalenone; T-2- and HT-2-toxin; fumonisins (B1 and B2); alternariol and alternariolmethylether; ergot alkaloids (six forms in their R- and S-enantiomer forms: alpha-ergocryptine/-inine, ergocornine/-inine, ergocristine/-inine, ergometrine/-inine, ergosine/-inine, ergotamine/-inine); and patulin. Mycotoxins were analysed using a liquid chromatography-tandem mass spectrometry method (triple-quadrupole-LC-MS/MS). Patulin was analysed separately since a specific column is used for sample clean-up before analysis. All other mycotoxins were analysed in the same LC-MS/MS run and with the same sample extraction and clean-up (see A 4.14). LOQ are shown in Table 46.

Table 46. Limits of quantification (LOQ) for determination of mycotoxins in the Market Basket 2022.

Substance	LOQ (µg/kg)
Aflatoxin B1	0.5
Aflatoxin B2	0.5
Aflatoxin G1	0.5
Aflatoxin G2	0.5
Ochratoxin A	0.3
Deoxynivalenol	50
15-acetyldeoxynivalenol	100
3-Acetyldeoxynivalenol	100
Zearalenone	5
T-2 toxin	5
HT-2 toxin	5
Fumonisin B1	100
Fumonisin B2	100
Alpha-Ergocryptine/-inine	2
Ergocornine/-inine	2
Ergocristine/-inine	2
Ergometrine/-inine	2
Ergosine/-inine	2
Ergotamine/-inine	2
Alternariol	3
Alternariol monomethyl ether	3
Patulin	5

8.16.1 Concentrations in food groups

Mycotoxins in levels above LOQ were rare in the analysed samples and were only found for ergot alkaloids (five of six analysed forms) in the food group cereal products as well as for ochratoxin A in one sample of the fruit group. In Table 47 the results for individual ergot alkaloids as well as the total sum are presented. Values are presented for each ergot alkaloid as the sum of the R- and S-enantiomers.

Table 47. Concentrations of ergot alkaloids in the food group cereal products in the Market Basket 2022 (N=3 samples per food group).

		Cereal products
Alpha-Ergocryptine/-inine (µg/kg)	Mean	3.0
	Min	2.5
	Median	2.7
	Max	3.7
Ergocornine/-inine (µg/kg)	Mean	3.3
	Min	2.7
	Median	2.7
	Max	4.4
Ergocristine/-inine (µg/kg)	Mean	7.1
	Min	4.9
	Median	5.5
	Max	11
Ergometrine/-inine (µg/kg)	Mean	0
	Min	<2
	Median	<2
	Max	<2
Ergosine/-inine (µg/kg)	Mean	5.3
	Min	3.9
	Median	4.0
	Max	8.0
Ergotamine/-inine (µg/kg)	Mean	5.2
	Min	3.6
	Median	4.1
	Max	8.0
Total ergot alkaloids (ine/inine forms) per sample (µg/kg)	Mean	24
	Min	18
	Median	18
	Max	35

To obtain a basis for risk assessment of mycotoxins with levels below LOQ, instrumental outputs are presented in Table 48. This is in accordance with the previous market basket study. These levels are based on specific chromatographic peaks, but values are less exact, and the substance identity cannot be fully verified. Therefore, values can only be used as a provisional scenario for exposure assessment. However, they are considered more accurate than using default values like LB or MB when toxins are present but in levels consistently below LOQ (Pustjens et al., 2022).

Table 48. Instrument levels of mycotoxins in two food groups in the Market Basket 2022 (N=3 samples per food group). Data are presented regardless of LOQ.

		Cereal products	Fruits
Aflatoxin B1 (µg/kg)	Mean	0.02	0
	Min	0.01	0
	Median	0.01	0
	Max	0.02	0.01
Aflatoxin total (µg/kg)	Mean	0.03	0.03
	Min	0.03	0.01
	Median	0.04	0.03
	Max	0.04	0.06
Ochratoxin A (µg/kg)	Mean	0.08	0.42
	Min	0.07	0.04
	Median	0.08	0.07
	Max	0.11	1.2[1]
Deoxynivalenol (µg/kg)	Mean	21	0
	Min	18	0
	Median	22	0
	Max	23	0
Zearalenone (µg/kg)	Mean	1.3	0.49
	Min	0.98	0.19
	Median	1.0	0.43
	Max	1.9	0.85
T-2 and HT-2 toxin (µg/kg)	Mean	1.2	0.05
	Min	0.89	0.03
	Median	1.3	0.03
	Max	1.5	0.09
Fumonisin B1 (µg/kg)	Mean	1.0	0
	Min	0.16	0
	Median	0.78	0
	Max	2.1	0

[1] Level above LOQ

Levels of aflatoxin B2, 15-acetyl-DON, 3-acety-DON, fumonisin B2, patulin and alternariol monomethylether were not detected in any sample. Alternariol was detected in one sample of the fruit group only, 1.3 µg/kg.

8.16.2 Exposure estimations

The exposure assessments for the respective food group and mycotoxin are shown in Table 49. Since the TDI for ergot alkaloids, T-2 and HT-2 toxins and for fumonisins are group TDIs (see Table 50), the per capita intakes for these three groups of mycotoxins are shown as the sum of the toxins included in the group TDI. The TDI for DON is also a group TDI, including the modified forms 3-acetyl-DON, 15-acetyl-DON and DON-3-glucoside. However, the acetylated forms were not detected in any sample and the glucoside form is not included in the analysis. Presented values are therefore only for DON. Since patulin and alternariol monomethylether were not detected in any sample, and alternariol only in one, these mycotoxins were not included in the exposure estimation.

Mycotoxins have been included in the market basket study one time previously, 2015 (Swedish Food Agency, 2017), and the resulting per capita intakes from that study are also presented in Table 49. For additional comparison, the latest exposure estimations performed by EFSA of the respective mycotoxins are also presented. The EFSA results are based on data from all EU member states and are shown as minimum lower bound to maximum upper bound values across the food consumption studies included in the assessment. Both average and the high exposure estimates (95th percentile) are presented.

Table 49. Per capita intake of mycotoxins from two different food categories (cereal products and fruit) in the Market Basket 2022 and comparison with Market Basket 2015 and EFSA estimations.

	Market basket 2022 Per capita intake (ng/kg bw/day)			Market basket 2015 Per capita intake (ng/kg bw/day)			EFSA Intake[1] (ng/kg bw/day)		Year
	Cereals	Fruits	Total	Cereals	Fruits	Total	Average	P95	
Total ergot alkaloids	77	NA	77	NA	NA	NA	10-180	20-360	2017a
Aflatoxin B1	0.05	0.01	0.06	0.12	0.04	0.16	0.22-3.25	0.62-6.78	2020a
Total aflatoxin	0.11	0.10	0.21	0.18	0.52	0.71	0.32-6.6	0.79-14.24	2020a
Ochratoxin A	0.27	1.3	1.6	0.3	0.4	0.7	1.7-6.0	3.9-12.7	2020b
Deoxynivalenol	68	0	68	133	28	161	300-700[2]	500-1400	2017c
Zearalenon	4.2	1.5	5.7	11	13	24	2.4-29	4.7-54	2011
T-2 and HT-2 toxin	4.0	0.16	4.2	5.4	7.9	13	2.54-26	6.4-54	2017b
Fumonisin B1 (and B2)	3.2	0	3.2	22	1.3	24	30-1190[3]	80-2300	2014

P95, 95th percentile; NA, not analysed

[1] Minimum LB to maximum UB intake for adult consumers.

[2] Sum of DON, 3-Ac-DON, 15-Ac-DON and DON-3-glucoside.

[3] Contribution from maize and maize products only.

Comparing the Market Basket results from 2015 and 2022, all intake levels are lower in the later study except for ochratoxin A. It is uncertain if this is a downward trend, a result of natural variations or due to measurement uncertainties due to values below LOQ. Mycotoxin levels in food can vary largely between years depending on weather conditions during the growing season for instance. Moreover, mycotoxins are usually very heterogeneously distributed in food which contribute to uncertainty since only a few samples are analysed.

Most intake levels in the Market Basket 2022 are in the lower range of the EFSA average intakes, or in some cases under the lowest EFSA intake level. The high consumption level (i.e. 95th percentile) in the EFSA assessments shows significantly higher intakes than the Market Basket values. This is expected since the Market Basket only includes per capita intake, and no upper bound levels are used for calculating the intake.

Cereals are the main contributing food group for all mycotoxins except for aflatoxins and ochratoxin A. This is in line with other assessments which consistently show that cereals are the main contributor to mycotoxin exposures. Aflatoxins and ochratoxin A for instance occur in nuts and dried fruits, which are included in the fruit group, but they also occur in cereals.

8.16.3 Risk assessment

Current TDIs established by EFSA for analysed mycotoxins are presented in Table 50. As a measure of the risk associated with the present levels of mycotoxins in the Market Basket analysis the estimated per capita intakes are expressed as percentage of the TDI.

In most cases, i.e. for DON, zearalenone, T-2 and HT-2 and fumonisin B1, the estimated intake makes up less than 10% of the TDI, indicating that there is a large margin before the risk of negative health effects increase. Ergot alkaloids have the highest percentage of the TDI in this analysis, 13%. While this does not indicate a risk at per capita level, it is still interesting. Ergot alkaloids are strongly correlated with rye which makes up a small proportion of the cereal product group. Also, in a risk assessment of ergot alkaloids EFSA et al. (2017) concluded that children (infants, toddlers, and other children) had a 2-3 times higher chronic dietary exposure than other consumer groups, which might indicate that the intake is underestimated for children. The estimation for DON is probably also an underestimation for some consumer groups. Human biomonitoring data has shown that DON is one of the mycotoxins to which the Swedish population has the highest exposure. About 1% of participating adults, and 1.6% of adolescents, exceeded the TDI for DON in the most recent biomonitoring studies (Wallin et al., 2013, Warensjö Lemming et al., 2020).

Table 50. Tolerable daily intakes (TDIs) according to EFSA and risk assessment expressed as percentage of TDI.

	TDI (ng/kg bw/day)	TDI (%)[1]	Reference
Total ergot alkaloids	600	13	EFSA (2012d)
Deoxynivalenol	1000	6.7	EFSA (2017b)
Zearalenon	250	2.3	EFSA (2011)
Total T-2 and HT-2	100	4.2	EFSA (2017a)
Fumonisin B1 (B2)	1000	0.32	EFSA (2018c)

[1] Estimated per capita intakes are expressed as percentage of TDIs as a measure of the risk associated with occurring levels of mycotoxins in the Market Basket analysis

Aflatoxins and ochratoxin A are genotoxic and carcinogenic substances and therefore no TDIs are set. Instead, the MOE approach is used by EFSA.

For ochratoxin A, EFSA (2020c) used a BMDL of 14.5 µg OTA/kg bw/day as a reference point for the risk characterisation, based on increased combined incidences of adenomas and carcinomas in rats. In the EFSA assessment, this resulted in MOE values that ranged from 8735-2405 for the exposure assessment of average adult consumers, minimum LB to maximum UB. The estimated intake of OTA in the Market Basket 2022 (1.6 ng/kg bw/day) gives a MOE of 9063.

For aflatoxins, EFSA (2020b) used a BMDL of 0.4 µg AFB1/kg bw/day based on induction of liver cancer in rats. The same potency was assumed for B and G forms of aflatoxin. Resulting MOEs for the EFSA exposure assessment of AFB1, average adult consumers, minimum LB to maximum UB, were 1818-123. Market Basket intake levels (0.06 and 0.21 ng AFB1 and AF total respectively) gives MOEs of 8 735 (AFB1) and 1904 (AF total).

For substances that are genotoxic and carcinogenic MOEs below 10 000 indicates a possible health concern. Consequently, the results from the Market Basket 2022 indicate that average intake levels of both OTA and aflatoxins in the Swedish population might be too high in relation to carcinogenic effects. As mentioned above however, the calculations are performed with unvalidated data and coming from a small number of samples. Uncertainty in the assessment is therefore high.

8.16.4 Conclusion

The average exposure to mycotoxins is generally low in the Swedish population. Intake levels do not indicate health concerns for ergot alkaloids, DON, T-2/HT-2, fumonisins, Alternaria toxins or patulin. These results are in agreement with the Market Basket 2015. Intakes of aflatoxins and ochratoxin A are also low when comparing with EFSA exposure assessments, a possible health concern is however indicated by the current MOE calculations.

Market Basket data do not include high consumers or different age groups. EFSA assessments show that high consumers might exceed the TDI for several mycotoxins, and that children are generally more exposed to mycotoxins than adults. Additional uncertainty is added by the fact that only two food groups have been analysed. Mycotoxins can be found in a wide range of foods and some important sources such as pulses, vegetables, oil seeds, milk and milk products, beverages such as beer, wine and coffee are missed in this analysis. For these reasons, the Market Basket risk estimate for mycotoxins may be an underestimation for some consumer groups.

8.17 Fluoride

Fluoride exposure via food in the general population is mainly attributed to drinking water, although other foods may also contribute. Fluoride is not essential for human growth and development but has been identified as protective against caries and tooth decay (EFSA, 2013). Fluoride has not previously been measured in a market basket study and there are to our knowledge no standardized methods to measure fluoride in food at low concentrations. In Market Basket 2022, fluoride in food was analysed with a new method developed at Linköping University using gas-chromatography tandem mass spectrometry (GC-MS/MS) (Kikuchi et al. In prep). The method is described in more detail in Appendix 4 (section A 4.15). LOD and LOQ are shown in Table 51.

Table 51. Limits of detection and quantification for analyses of fluoride in the Market Basket 2022.

Fluoride (µg/kg)	
Limit of detection (LOD)	Limit of quantification (LOQ)
0.19	18

8.17.1 Concentrations in food groups

Fluoride concentrations in the food groups are presented in Table 52. Lean fish contained the highest levels of fluoride, followed by coffee and tea. The mean level in lean fish was 833 µg/kg and in coffee and tea was 700 µg/kg (Table 52). The high level of fluoride in coffee and tea did not exclusively come from the water used in brewing since the water only had a level of 89 µg fluoride/kg.

Table 52. Levels of fluoride in the different food groups in the Market Basket 2022.

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Coffee and tea
Fluoride	Mean	67	0	52	833	107	353	0	0	30	0	61	13	190	0	134	700
(µg/kg)	Min	52	<18	39	650	42	230	<18	<18	<18	<18	<18	<18	100	<18	92	620
	Median	53	<18	39	870	130	400	<18	<18	<18	<18	43	<18	200	<18	130	710
	Max	71	<18	77	980	150	430	<18	<18	71	<18	130	22	270	<18	180	770

Fluoride was not analysed in beverages.

< indicates a value below limit of quantification (LOQ). When calculating means, hybrid bound approach was used. This means that medium bound concentration (0.5*LOQ) was imputed for non-detects, with exception for when all three samples in one food group had concentrations below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

8.17.2 Exposure estimations

The estimated total exposure from all food groups analysed in the Market Basket 2022 was 383 µg/day (Table 53). The coffee and tea group was the largest contributor to the fluoride exposure, accounting for 76% of the total exposure (Figure 42). For most people, the primary source of exposure is likely drinking water, but the food group coffee and tea (probably tea) could be a significant contributor among high consumers. In Sweden, water is not fluoridated and the fluoride content varies geographically. The median value in water from large water producers in Sweden is 250 µg/L, with the 90th percentile at 1100 µg/L (Thunholm and Whitlock, 2014). The water used in the market basket study only had a fluoride concentration of 89 µg/L. When combining exposure from food with water at the Swedish median level and assuming a standard consumption of 2 L per day (EFSA, 2010b) , the total exposure would be 883 µg/day. This estimate aligns reasonably with estimations of the mean exposure in the Norwegian population of approximately 1000 µg/day (VKM et al., 2019). Using the 90th percentile value of fluoride in drinking water, the exposure would be 2583 µg/day. This estimate excludes fluoride exposure from toothpaste and other dental products. Additionally, the fluoride content in beverages is not included in this estimate since it was not analysed in the Market Basket 2022. However, this underestimation of intake is partly counteracted by that water used for brewing coffee and tea is not included in the consumption of drinking water and beverages.

Table 53. Mean daily intake of fluoride from food groups and total intake in the Market Basket 2022 (N=3 per food group).

Food group	Per capita consumption (g/person/day)		Per capita intake (µg/person/day)
Cereal products	226		15
Pastries	55	LB HB UB	0 0 0.99
Meat	194		10
Lean fish	15		12.5
Fatty fish	18		1.9
Meat substitutes	3		1.1
Lean dairy products	248	LB HB UB	0 0 4.5
Fatty dairy products	70	LB HB UB	0 0 1.3
Plant-based drinks	13	LB HB UB	0.31 0.39 0.46
Eggs	29	LB HB UB	0 0 0.52
Fats and oils	55	LB HB UB	3.2 3.3 3.5
Vegetables	245	LB HB UB	1.8 3.3 4.7
Fruits	215		41
Potatoes	142	LB HB UB	0 0 2.6
Sugar and sweets	74		9.9
Coffee and tea	407		285
Total		**LB** **HB** **UB**	**382** **383** **394**
µg/kg bw/day		**HB**	**5.5**

LB, lower bound (i.e. 0 is used for non-detects); HB, hybrid bound (i.e. 0.5*limit of detection (LOD) is used for non-detects, except for when all three samples in one food group have concentrations below LOD. In those cases, lower bound (0) was imputed for non-detects); UB, upper bound (i.e. LOD is used for non-detects). A body weight of 70 kg was assumed when estimating the body weight adjusted intake.

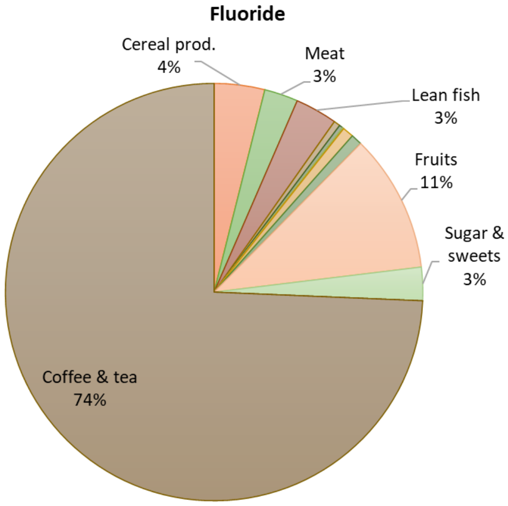

Figure 42. Percentage contribution to the per capita intake fluoride from different food groups in the Market Basket 2022.

Food groups contributing less than 1% are only presented graphically in the pie chart, and not with text. The percentage is based on mean per capita intake per food group. Hybrid bound were used when calculating means (i.e., medium bound concentration [0.5*limit of detection, LOD] was imputed for non-detects, with exception for when all three samples in one food group had concentrations of a mineral below LOD. In those cases, lower bound (0) was imputed for non-detects when calculating mean).

8.17.3 Risk assessment

Risk assessments of fluoride do not generally consider intake from food, as drinking water it's presumed to be the primary source of exposure. While fluoride has positive effects on caries prevention, it can cause dental fluorosis in children and osteofluorosis in adults. EFSA has set the UL for children up to 8 years old at 0.1 mg/kg bw/day for the effect of dental fluorosis and for adults at 0.12 mg/kg bw/day based on the effect osteofluorosis (EFSA, 2005c). There is a very narrow margin between existing adequate and upper intake levels (0.05 mg/kg bw/day for AI and 0.1 mg/kg bw/day for UL). The estimated exposure from food in this market basket study was 5.5 µg/kg bw/day, which is substantially lower than the UL. It is therefore unlikely that exposure from food alone will cause toxicity in the general Swedish population. However, fluoride levels in Swedish drinking water vary, with 10% of the population consuming water above 1.1 mg/L. A standard drinking water consumption of 2 L (Thunholm and Whitlock, 2014) of the 90th percentile in combination with exposure from food would result in an exposure of 37 µg/kg bw/day for a person weighing 70 kg. This is still substantially below UL. The provisional AR is 2.6 mg/day for women and 3.0 mg/day for men (Blomhoff et al., 2023), corresponding to a mean of 40 µg/kg bw/day. Hence, the estimated intake including consumption of drinking water with a high fluoride content, remains slightly lower than the provisional AR of 40 µg/kg bw/day, aimed at preventing dental caries and tooth decay. This indicates that the fluoride exposure in Sweden is more likely to be too low than too high.

8.17.4 Conclusion

Among all food groups, the highest concentrations of fluoride were found in lean fish and coffee and tea. When estimating total exposure from all food groups analysed in the Market Basket 2022 coffee and tea are the main source. This finding could not be attributed to the levels in the water used for brewing. Drinking water is considered the main source of fluoride exposure for the general Swedish population but is not included in the Market Basket 2022. The combination of fluoride concentrations in drinking water from large Swedish water producers and the results of the market basket study show that 15-43% of the intake could originate from foods (including coffee and tea). The estimated per capita intake of fluoride assuming 2 L drinking water per day was below the provisional AR, suggesting that the fluoride exposure in Sweden is more likely to be too low than too high from a dental health perspective. It should be noted that the method used for measuring fluoride in food is new.

8.18 Comparative risk characterization

The Swedish Food Agency has developed a tool, called the "Risk Thermometer", by which health concerns associated with chemical exposures can be compared (Swedish Food Agency et al., 2015). The Risk Thermometer was applied to several of the toxic compounds analysed in this market basket study, as well as the essential mineral elements and vitamins. Macronutrients were not included in the comparative risk characterization. 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 value. The availability and documentation of such reference values, i.e., toxicological reference values like TDIs (mainly from Efsa), and ULs and/or Lower intake levels (LIs) for the minerals and vitamins, determined the total number of compounds that could be part of this analysis (see Appendix 6). NNR 2023 does not define LI for nutrients. Therefore, the LI was calculated as AR - 1.96*standard deviations (SD), where SD=AR*coefficient of variation (CV)/100. A normal distribution of the requirement in the population was assumed and the CV is the variation. The ARs and CVs according to NNR were used, where CV is described in appendix 5 of NNR. For provisional ARs, a CV of 12.5% was assumed (Blomhoff et al., 2023). The estimated LI thereby corresponds to an exposure level that covers the requirement in 2.5% of the population.

The methodology in the Risk Thermometer is different compared to traditional chemical risk characterization in that the *severity* of the critical health effect (that the reference value is based on) is considered in a systematic manner, i.e. cancer is judged to be more serious than skin lesions, for example. The underlying risk metric in the Risk Thermometer is called the severity-adjusted margin of exposure (SAMOE). While this method was originally proposed for assessing chemical hazards, the concept was herein generalized to enable assessment of health concerns associated with excess or deficiency of vitamins and minerals. As a result, the equation for the SAMOE was extended as described below:

$$SAMOE_1 = \frac{TDI\ (or\ UL)}{E \times SF} \qquad (1)$$

$$SAMOE_2 = \frac{E}{LI \times SF} \qquad (2)$$

Equation (1) is applied for substances with a TDI, or similar, and substances with an UL, while Equation (2) is applied for compounds with an LI. $SAMOE_1$ corresponds to the original equation in simplified form. In contrast to previously described (Swedish Food Agency et al., 2015), the TDI (or UL) is herein directly introduced rather than the individual parameters (i.e., the reference point and adjustment factors) behind this value. E is the estimated per capita exposure expressed per kg body weight and day. A body weight of 70 kg was used as a standard across all exposures. Severity factor (SF) describes the severity of the critical health effect that the TDI, UL, or LI is based on. This parameter distinguishes the SAMOE from traditional risk characterization. A 5-graded severity scale, C1 through C5, with associated severity factors, SFs, of 1, 3.2, 10, 32 or 100 was used. The classification of the critical effect in any of the five severity categories is guided by a health effect classification scheme. A new 5-graded scale, describing broad effect groups, was applied in this work (Sand et al., 2018, Sand, 2022). To address deficiency $SAMOE_2$ is inversed compared to $SAMOE_1$ with regard to the reference value and the exposure. For a given exposure, when the severity of the effect increases the SAMOE decreases (and the health concern increases) under both equations 1 and 2. TDIs (or equivalents), ULs, LIs, and severity categories used as part of the analyses are given in Appendix 6.

While there is uncertainty in the parameters that define SAMOE, the present analysis mainly focuses on the point estimate due to limited quantitative information of uncertainty related to the TDIs, ULs, and LIs for many of the compounds included. However, uncertainty in the per capita exposure related to values below the LOD/LOQ was accounted for when applicable, i.e., a uniform uncertainty distribution was then assumed using LB and UB as the lower and upper limits, respectively, and otherwise the HB estimate was used as a point estimate, only. It is realised that this comprises only a part of the overall uncertainty related to the exposure. Also, the SF was for some compounds described in terms of a uniform uncertainty distribution, rather than a single value, in case the severity classification in C1 - C5 was regarded to be uncertain. As an example, if the critical effect was classified in either C1 or C2, a uniform uncertainty distribution for SF was assumed with lower and upper limits of 1 and 3.2, respectively (as noted above, C1 - C5 links to SFs = 1 -100). Accounting for these uncertainties, the SAMOE (equation 1 or 2) was evaluated using Monte Carlo simulations providing a SAMOE point estimate and a 90% confidence interval.

The point estimate of SAMOE was classified in one of five risk classes. These risk classes describe different levels of health concern. Exposure that are categorised in risk classes 1 and 2 are not regarded to represent a health risk. Risk class 3, in the middle of the scale, is regarded to represent a grey zone. Exposure that are categorised in risk class 4 and 5 may represent potential health risks or indicate exposures that are higher or lower than desirable.

The risk ranking results are shown in Table 54. The Risk Thermometer approach could be applied for 69 compounds, i.e., 35 substances with toxicological reference values like TDIs, and 15 and 19 compounds with ULs and/or LIs, respectively. Two compounds classified in Risk Class 4; twelve compounds classified in Risk Class 3; and the remaining fifty-five compounds classified in Risk Class 2 (36 compounds) or Risk Class 1 (19 compounds). The top ranked compounds in Risk Class 4 were sodium, and dioxin-like compounds. Compounds with LIs appeared to be underrepresented in the higher risk classes, i.e., 1 of 19 compounds with LIs classified in Risk Class 3-4. For the toxic compounds 8 of 35 were classified in Risk Class 3-4, and a somewhat higher proportion of compounds with ULs classified in these risk classes, i.e., 5 of 15 compounds.

There are some caveats to the results in Table 54. The conducted risk ranking is a screening that generally should be interpreted at the level of the risk class. Whether results motivate some form of management action or not require additional case by case assessment since the approach may not fit all compounds equally well. For example, the dose range covering mild to severe effects is standardized to a factor 100 in the Risk Thermometer, i.e., the severity factor, SF, associated with severity category C1 through C5 range from 1 through 100. This approach fits less well in case the true dose range between “mild” and “severe” is clearly different from a factor 100. For example, such could be the case for mineral elements that are tightly regulated in the body. Ideally, this issue is assessed in a more chemical specific manner, which is realized in the developments of the Risk Thermometer idea (Sand et al., 2018, Sand, 2022). However, these more advanced versions of the method are data intensive, and it may not be possible to apply them to a large range of compounds as is done herein. Also, differences in the level of conservatism applied in the development of TDIs for toxic compounds could make the current risk ranking un-balanced. As noted earlier, the use of the Risk Thermometer was simplified in the sense that the TDI, or similar, was used directly rather than utilizing the parameters behind these values. Moreover, the ranking between compounds with TDIs and ULs are better calibrated than versus compounds with LIs. This is because LIs were derived in a different manner, as described above.

Also, exposure from water, which is not accounted for, could modulate the ranking for some compounds. For example, in the case of fluoride the additional contribution from water and fluorinated toothpaste would increase the margin to the LI, and thus lower the rank compared the present results. Conversely, in the case of PFAS-4 additional contribution from water would decrease the margin to the toxicological reference value, and thus decrease the SAMOE.

Table 54. Risk-ranking in the Market Basket 2022 according to the severity-adjusted margin of exposure (SAMOE) for sixty-nine compounds with toxicological reference values (Tox), or upper intake level (UL) and/or lower intake level (LI).

Compound	Type[1]	Risk Class	SAMOE[2]	LB	UB
Sodium	UL[3]	4	0.031	0.031	0.031
Dioxin-like compounds	Tox	4	0.074	0.064	0.086
Nickel	Tox	3	0.14	0.14	0.14
Fluoride	LI	3	0.18	0.18	0.19
Molybdenum	UL	3	0.21	0.12	0.35
Phosphorus	UL	3	0.22	0.13	0.37
Vitamin A[4]	UL	3	0.22	0.13	0.38
Acrylamide	Tox	3	0.26	0.24	0.27
Aluminium	Tox	3	0.45	0.45	0.45
Cadmium	Tox	3	0.49	0.49	0.49
Lead	Tox	3	0.51	0.47	0.54
Aflatoxin tot	Tox	3	0.60	0.60	0.60
Mercury	Tox	3	0.67	0.37	1.2
Selenium	UL	3	0.70	0.42	1.2
Folate	LI	2	1.0	0.95	1.1
PFAS-4	Tox	2	1.0	0.60	1.7
Iodine	LI	2	1.0	0.62	1.7
Calcium	UL	2	1.1	0.68	1.9
Iodine	UL	2	1.1	1.1	1.1
Fluoride	UL	2	1.2	0.73	2.1
Inorganic arsenic	Tox	2	1.3	1.2	1.3
Selenium	LI	2	1.3	1.2	1.4
Vitamin D	LI	2	1.5	1.4	1.7
Riboflavin	LI	2	1.6	1.6	1.6
Iron	LI	2	1.8	1.8	1.8
3-MCPD	Tox	2	1.8	1.0	3.2
Copper	UL	2	1.8	1.1	3.0
Zinc	LI	2	1.9	1.9	1.9
Magnesium	LI	2	2.1	2.1	2.1
Calcium	LI	2	2.1	2.1	2.1
Aflatoxin B1	Tox	2	2.1	2.1	2.1
Potassium	LI	2	2.2	2.2	2.2
Vitamin E	UL	2	2.4	1.4	4.1
Manganese	LI	2	2.7	2.7	2.7
BDE-153	Tox	2	2.7	1.3	6.0
Ochratoxin A	Tox	2	2.9	2.9	2.9
Copper	LI	2	3.2	3.2	3.2
Folate	UL	2	3.2	1.9	5.3
Vitamin A	LI	2	3.3	3.2	3.4
Vitamin E	LI	2	3.4	3.4	3.4
Vitamin K	LI	2	3.8	3.6	4.0

Compound	Type[1]	Risk Class	SAMOE[2]	LB	UB
Molybdenum	LI	2	4.2	4.2	4.2
Ergotalkaloides	Tox	2	4.4	2.6	7.4
Deoxynivalenol	Tox	2	4.7	4.7	4.7
BDE-99 (1)	Tox	2	6.1	3.7	10
Vitamin D	UL	2	6.9	4.1	12
HCB (2)	Tox	2	6.9	6.5	7.5
Total T-2 and HT-2	Tox	2	7.5	7.5	7.5
Phosphorus	LI	2	7.6	7.6	7.6
PCA SCCP (C10-C13)	Tox	2	9.0	7.0	12
Zearalenone	Tox	1	14	14	14
PAH4	Tox	1	16	15	17
CB153	Tox	1	16	16	16
Glycidol	Tox	1	19	16	23
Thiamine	LI	1	28	27	29
Benzo(a)pyrene	Tox	1	31	24	41
BDE-47 (1)	Tox	1	49	30	80
DINP	Tox	1	73	44	124
Manganese	UL	1	93	56	156
Fumonisins	Tox	1	111	66	187
BDE-209 (2)	Tox	1	278	140	555
PCA MCCP (C14-C17)	Tox	1	433	349	538
DDT-sum	Tox	1	551	191	1571
Silver	Tox	1	642	527	785
HBCDD	Tox	1	658	582	745
DINCH	Tox	1	1710	1021	2867
Zinc	UL	1	1786	1786	1786
BBzP	Tox	1	2632	926	7460
Iron	UL	1	4000	4000	4000

Compound specific considerations are referred to the chapter of each compound.

The SAMOE (equation 1 or 2) is presented as a point estimate and a 90% confidence interval (LB - UB) based on Monte Carlo simulations (N = 10,000 iterations). The risk ranking is based on the SAMOE point estimate, which is classified in five risk classes; Risk Class 1 (SAMOE ≥ 10), Risk Class 2 (SAMOE < 10 and SAMOE ≥ 1), Risk Class 3 (SAMOE < 1 and SAMOE ≥ 0.1), Risk Class 4 (SAMOE < 0.1 and SAMOE ≥ 0.01), and Risk Class 5 (SAMOE < 0.01).

[1] Tox: toxicological reference values for undesirable compounds. UL: upper intake level or safe level of intake for vitamins and minerals. LI: lower intake level for vitamins and minerals. See appendix 6 for more information.

[2] Risk classes 1 and 2 are not regarded to represent a health risk. Risk class 3 is regarded to represent a grey zone. Risk class 4 and 5 may represent potential health risks or indicate exposures that are higher or lower than desirable.

[3] For sodium, chronic disease risk reduction (CDRR), was used as health-based reference value. CDRR is a level below which it is expected to reduce chronic disease risk within the general population.

[4] UL for vitamin A is based on preformed vitamin A. Therefore, intake estimation of preformed vitamin A (all-trans-retinol) was used here.

8.18.1 Conclusion

This is the first time the risks for deficiency and excess intake of nutrients is included alongside other compounds as part of this comparative risk characterization. It is possible that the ranking between compounds with TDIs and ULs may be better calibrated than versus compounds with LI because of how these values are derived. The conducted risk ranking is a screening that generally should be interpreted at the level of the risk class. Whether results motivate some form of management action or not require additional case by case assessment. For example, the approach may not fit all compounds equally well or there may be other relevant routes of exposure not accounted for in this market basket study.

No compound was graded as Risk Class 5. Estimated per capita intakes of sodium, phosphorus and dioxin-like compounds were ranked highest (Risk Class 4). High sodium intake in the Swedish population is a well-known health problem (Brådvik et al., 2021, Institute for Health Metrics and Evaluation), which is reflected in the Market Basket 2022 despite that the intake is underestimated due to that household salt is not included (section 8.4). The per capita intake of dioxin-like compounds is also high in relation to the TWI (section 8.6). Both these sodium and dioxin-like compounds are also associated with health outcomes giving a high severity factor (chronic disease and reduced sperm quality, respectively), which also affect the ranking (Appendix 6). Decreasing time trends were seen for both these compounds in this market basket study compared with previous studies, which shows that their content in food and/or intakes are changing in the right direction. As in the Market Basket 2015, several unwanted metals were ranked in Risk Class 3 (Swedish Food Agency, 2017).

9 General method discussion

The Market Basket 2022 provides food group concentrations and population mean intake estimations of a wide range of nutrients and potentially harmful substances. It should be kept in mind that the intakes estimated in the market basket study only describes the average intake of a compound in the population. Hence, there are probably individuals in the population eating more or less of some food items (high and low consumers), causing a higher or lower intake than the average shown here. For example, individuals consuming larger amounts of fish, most likely have higher intakes of e.g. dioxins, brominated flame retardants, PFAS, and methylmercury than the per capita intakes reported here. They are therefore also probably at higher risk for an intake that may be a health concern. The market basket studies are also limited by not including intake estimations among children. Therefore, the dietary exposures are associated with uncertainties and can only be extrapolated to the adult population.

Nevertheless, the market basket study provides important data on concentrations in food groups, exposure estimations and time trend analyses central for e.g. risk and/or benefit assessments. The study is a useful screening tool providing analytical data and intake estimations for many compounds in a cost-effective way. For more in-depth knowledge about the exposure, the data provided in the Market Basket 2022 could be combined with food consumption data on individual level from dietary surveys and/or biomonitoring data. Also, individual foods known to contribute to the intake of specific substances should be analysed.

The Market Basket 2022 is the fifth Swedish market basket study conducted by the Swedish Food Agency using similar study protocols. There is a balance with continuously improving the methodology but to remain the method similar enough to be able to do the time trend comparisons. This time, we included three new food groups (meat substitutes, plant-based drinks, and coffee and tea). The food is generally not prepared in the market basket studies, but the coffee and tea were brewed since the powder/leaf is not consumed. Thereby, drinking water was partly included in the intake estimations of this market basket study despite that drinking water is not included otherwise. To avoid use of contaminated brewing water, the water treatment plant was chosen based on levels of e.g. PFAS and fluoride, since these are known to fluctuate geographically. The coffee and tea group was not included in the time trend analyses. Because fish is an important contributor to several compounds analysed in the market basket studies, we also separated fish into two groups (one for lean fishes, including shellfish, and one for fatty fishes). The Market Basket 2022 resembles total diet studies and has been conducted in agreement with the guidelines established to harmonise total diet studies as much as possible (World Health Organization et al., 2011). However, one major discrepancy is that total diet studies analyse foods as they are commonly consumed (e.g. boiled pasta, fried meat etc.) whereas the market basket studies include foods as purchased (e.g. raw pasta, raw meat).

Major limitations and uncertainties associated with the results presented in this report are presented in Table 55. The health-based reference values used to estimate the health risk of the intakes are primarily produced by international scientific organisations (e.g. EFSA, WHO, NNR Committee). Exceedance of a health-based reference value does however not directly imply adverse health effects, but rather indicate that the margin of safety is small.

The per capita intake is a function of both consumption and concentrations. Therefore, time trends could be a consequence of changes in consumption and/or concentrations. It is therefore important that the consumption data used is reasonably accurate. To investigate accuracy of the consumption data used in the Market Basket 2022, they were compared with data from the dietary survey Riksmaten adults 2010-11 (Amcoff et al., 2012). Foods reported in Riksmaten adults 2010-11 were grouped into the food groups used in the Market Basket 2022. Because food is reported as consumed in dietary surveys but as purchased in the market basket study, yield factors were used to convert cooked items in dietary survey data (such as pasta) to raw weights. The total consumption in the Market Basket 2022 (including coffee and tea) was 2271 g/day, which could be compared to a mean total consumption of 1911 g/day in Riksmaten adults 2010-11 (excluding tap water and alcoholic beverages ≥ 3.5 volume% alcohol, which are not included in the market basket study), data not shown. This is 16% below the consumption in the Market Basket 2022. A lower consumption in the dietary survey is expected due to e.g. differences explained by food waste and the risk of underreporting in dietary surveys (Poslusna et al., 2009). There have been small fluctuations between different market basket studies regarding total amount of foods consumed, which also can have an impact on the intake assessment when investigating time trends. For example, total per capita consumption was 2.0 kg/person/day in the Market Basket 2015, whereas it was reduced to 1.9 kg/person/day (excluding coffee and tea) in the present study. This could partly be a consequence of a larger awareness of food waste in the households, a true change in consumption, or both. The impact of food waste on the intake estimations in the present report differs depending on substance and in which food groups the substance is most present. The most frequent foods in household food waste are coffee/tea, followed by dairy products and beverages (juice, soda, alcoholic beverages) (Åkerblom et al., 2021), i.e. food groups often associated with lower concentrations of the substances analysed in this market basket study. A discrepancy compared with previous market basket studies is that a different data source was used for fish consumption (Hornborg et al., 2021). Fish is an important contributor to the intake of many substances, and a decrease in consumption was seen between 2015 and 2022. This could be due to the change of data source but also a true decrease (Hornborg et al., 2021). Sensitivity analyses using similar fish data source as in previous market basket studies were therefore performed in time trends analyses when suitable.

Table 55. Overview of main limitations or uncertainties in the Market Basket 2022 and their possible implications on the results.

Limitation/uncertainty	Possible implication/consequence	Attempt to minimize limitation/uncertainty
Chemical analyses have a measurement uncertainty, sometimes up to 30-50%.	Can cause both under- and overestimation of intake.	Use of accredited methods when available. Three samples per food group were analysed and means used in the calculations.
Many compounds are found in concentrations below detection or quantification limits.	The lower bound estimations may underestimate the intake and the upper bound estimations may overestimate the intake. The hybrid bound estimations may be under- or overestimations.	Per capita intakes are estimated using ranges (lower and upper bound approaches, as recommended by (World Health Organization et al., 2011)) as well as hybrid bound.
Food items are analysed raw and not as consumed. The reasons are to not break the time trend of market basket studies and also economical/practical.	Some vitamins seem to increase during preparation (e.g. vitamin E) and are probably underestimated, whereas other may be lost during heating (e.g. thiamine, riboflavin) and could be overestimated. Compounds generated or added during frying/cooking (e.g. acrylamide, PAH) or via tap water during cooking (e.g. PFAS, fluoride) are probably underestimated. Many unwanted substances are resistant and therefore probably not so affected. Concentrations of compounds could be higher due to water loss during e.g. frying.	None, but four food groups (cereal products, meat, fish, potatoes) were prepared and analysed both raw and as consumed in a pilot study of Market Basket 2015. There were no major changes in minerals, unwanted metals and PCB (Swedish Food Agency, 2017).
Population mean intakes are determined and information about e.g. high consumers are missing.	There are probably people at higher risk in the population. Therefore, a larger margin to health-based guidance values may be needed to also consider high consumers. See section 9. General method discussion above.	Comparisons have been made to intake estimates from national dietary surveys or assessments by EFSA and other organizations, when possible.
Intake estimations in children are not included.	Because children are growing, they often have a higher consumption in relation to their body weight than	None

Limitation/uncertainty	Possible implication/consequence	Attempt to minimize limitation/uncertainty
	adults. Therefore, children can be closer to health-based guidance values than estimated here. Reference points are however often set for long-term exposure during a lifetime.	
No adjustments are made for household´s food waste.	Probably overestimate intake.	Inedible food parts were removed. The body weight (70 kg) used in the body weight adjusted intakes is lower than the mean weight in the adult population (approximately 77 kg, see Appendix 2). Possible impact on the intake of substances close to reference points were discussed above.
The per capita consumption from the SBA is calculated by dividing the statistics with the entire Swedish population, also including children.	Probably underestimate the per capita consumption.	The underestimation is probably also counteracted by not adjusting for household´s food waste overestimating the consumption. Also, the body weight (70 kg) used to adjust intakes resembles mean body weight in the population estimated taking the whole population distribution into account (see Appendix 2), which gives a higher consumption in adults per body weight.
Intake from tap water, alcoholic beverages ≥3.5 volume alcohol, and household salt is not included.	Probably underestimates the total exposure of some substances (e.g. PFAS, fluoride).	Sodium intake is also estimated including statistics for household salt (see section 8.4.3).
Home production of food is not included in the consumption.	Probably underestimates the consumption of some food groups.	None
Because average requirements and recommended intakes are not available for some nutrients, provisional average	Probably underestimate the margin to sufficient intake of nutrients concerned (vitamin E, vitamin K, I, K, Mg, Mn, Mo, P, Se) (Blomhoff et al., 2023).	None

Limitation/uncertainty	Possible implication/consequence	Attempt to minimize limitation/uncertainty
requirements and adequate intakes are used. These reference values tend to overestimate the requirements.		
The chemical analyses used in the time trends are performed at different years. For some compounds, the detection and quantification limits differ between studies.	No impact on the estimates of Market Basket 2022 but increases the uncertainty in the time trends, especially for substances with concentrations close to or below the detection or quantification limit.	As much as possible, we aimed to use accredited laboratories, the same laboratories for each substance, and low detection or quantification limits.
Foods were purchased in one city (Uppsala) and during one season (September-November) only. In the previous two latest market basket studies, foods were purchased during spring.	May increase the uncertainty in the time trends. However, previous market basket studies have shown small regional and seasonal variations (Swedish Food Agency, 2017).	Different batches were used. Also, household and sale statistics at national level was used to select brands to increase the national representativeness of the samples.
The type of reference value (TDI, UL and LI) used in the risk comparison may be derived using different methods and are associated with different health risks.	Could have an impact on the ranking.	A severity factor was applied to the reference value when calculating SAMOE to account for differences in associated health effects. The conducted risk ranking is a screening that generally should be interpreted at the level of the risk class

10 Overall conclusion

The Market Basket 2022 is a useful and cost-effective screening tool providing concentration data and intake estimations for a wide range of nutrients and potentially harmful substances. It shows that the estimated per capita intakes of most of the analysed nutrients and unwanted substances are within the ranges that do not indicate a health risk in the general population. However, intakes of dioxins, salt and saturated fat were higher than the health-based guidance value or recommendations. Also, the intake of acrylamide indicated a concern for public health, despite the fact that the intake is underestimated. The intake of the sum of PFAS-4 stands for approximately half of the intake of all PFAS detected in the current market basket study, indicating that health-based guidance values for more PFAS than PFAS-4 is of importance.

Per capita intakes of sodium and dioxin-like compounds were ranked highest in the comparative risk characterization. However, decreasing time trends were seen for these compounds. It should be noted that intakes of high and low consumers or specific groups, such as children, are not considered in the market basket study.

Compound specific conclusions are:

- The per capita intakes of most vitamins and minerals are in consonance with the recommended values. Intakes of salt and saturated fat was higher than recommendations, but salt intake seems to decrease over time.
- The estimated intakes of most metals were below levels indicating a health risk. The intakes of cadmium and inorganic arsenic were close to the guideline for when there is a risk of adverse health effects. The intakes of these were higher than in previous market basket studies.
- The per capita intake of dioxins is at the same level or exceeds the tolerably weekly intake established by EFSA, but it decreases over time.
- The estimated intakes of per- and polyfluoroalkyl substances (PFAS) show declining time trends, and the estimated per capita intake of PFAS-4 is below the EFSA's tolerably weekly intake. The intake of the sum of PFAS-4 accounts for approximately half of the total intake of all detected PFAS. Exposure from drinking water is not included.
- The per capita intake of acrylamide is likely an underestimation of the true intake. Despite this, the results indicate concern for public health from acrylamide intake.
- The intakes of polycyclic aromatic hydrocarbons (PAHs) are probably underestimated but the margin to the critical effect is large. Therefore, the risk for health effects is low.

- Estimated intakes of mycotoxins indicate no health concern in the general population, except possibly for aflatoxins and ochratoxin A. The intakes are however uncertain because most levels were below the limit of quantification, only two food groups were included and the occurrence of mycotoxins in foods are various and sporadic.
- The intake estimation of fluoride shows that food, including coffee and tea, could contribute to about 15-43% of the intake. The intakes suggest that the fluoride exposure in general in Sweden is more likely to be too low than too high from a dental health perspective.
- The intake estimations of the following compounds indicate a safe margin to the reference points and no public health concern: organochlorine pesticides (hexachlorobenzene and p,p'-DDE), brominated flame retardants (PBDEs and HBCDD), chlorinated paraffins (PCAs), organophosphate flame retardants (PFR), plasticizers, 3-MCPD and glycidol.

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Appendices

Appendix 1.	Food list describing foods in the Market Basket 2022
Appendix 2.	Calculation of population mean body weight
Appendix 3.	Overview of samples per compound and food group
Appendix 4.	Description of chemical analytical methods used in the Market Basket 2022
Appendix 5.	Concentrations of additional chemical compounds analysed in the Market Basket 2022
Appendix 6.	Data used in the comparative risk characterization
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Appendix 1. Food list describing foods in the Market Basket 2022

The table describes included foods per food group, amount of each food per sample, waste applied, and statistical source of the foods and products included in the Market Basket Study 2022.

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Cereal products						
Fluor	2 products/sample	19	0	19	8	Nielsen IQ, online trades
Rice, polished	2 products/sample	17	0	17	7	Nielsen IQ, online trades
Rice, whole grain	1 product/sample	0.9	0	0.9	0.4	Online trades
Oats	1 product/sample	12	0	12	5	Nielsen IQ
Macaroni	2 products/sample	17	0	17	8	Nielsen IQ, online trades
Spaghetti	2 products/sample	10	0	10	5	Nielsen IQ, online trades
Muesli	2 products/sample	4	0	4	2	Nielsen IQ, GfK, online trades
Breakfast cereals	1 product/sample	2	0	2	0.9	Nielsen IQ
Cornflakes	1 product/sample	0.5	0	0.5	0.2	Nielsen IQ
Popcorn	1 product/sample	0.8	0	0.8	0.4	Online trades
Crisp bread	3 products/sample	9	0	9	4	Nielsen IQ, online trades
Soft bread, not the keyhole	3 products/sample	95	0	95	42	GfK
Soft bread, the keyhole	1 product/sample (2 batches/product)	41	0	41	18	GfK
Total		**226**		**226**	**100**	
Pastries						
Cookies	2 products/sample	9	0	9	17	Nielsen IQ, online trades
Crackers	2 products/sample (1-2 batches/product)	6	0	6	10	Nielsen IQ, online trades
Gingerbread	1 product/sample	3	0	3	5	Nielsen IQ
Cinnamon rolls and other doughy pastries	2 products/sample (1-2 batches/product)	15	0	15	27	Nielsen IQ, online trades
Pastries	2 products/sample (1-2 batches/product)	6	0	6	10	Nielsen IQ, online trades
Soft cakes like sponge cake	1 product/sample	6	0	6	10	Nielsen IQ
Pizza	2 products/sample	8	0	8	14	Nielsen IQ, online trades

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Hand pie	1 product/sample (3 batches/product)	4	0	4	7	Nielsen IQ, online trades
Total		**55**		**55**	**100**	
Subgroup: pizza, hand pie						
Pizza	2 products/sample (3 batches/product)	8	0	8	67	Nielsen IQ, online trades
Hand pie	1 product/sample (3 batches/product)	4	0	4	33	Nielsen IQ, online trades
Total		**11**		**11**	**100**	
Meat						
Ground beef	Sweden (Ireland for 1 sample)	26	0	26	14	Available in store
Minute beef steak	Sweden	2	0	2	1	Available in store
Beef shank	Sweden	1	10	1	0.7	Available in store
Pork tenderloin	Denmark	4	0	4	2	Available in store
Pork loin	Sweden (70% without bones)	7	35	5	3	Available in store
Pork chop	Sweden (40% without bones)	4	25	4	2	Available in store
Pork flare fat	Sweden (Germany for 1 sample)	9	0	9	5	Available in store
Ground pork	Sweden	10	0	10	5	Available in store
Ground lamb	Sweden (Ireland for 1 sample)	3	0	3	2	Available in store
Whole chicken, with skin	Sweden	18	30	13	7	Nielsen IQ, online trades
Chicken breast	Sweden (2 batches/product)	37	0	37	19	Nielsen IQ, online trades
Moose shavings	Sweden (deer from New Zeeland for 1 sample)	6	0	6	3	Available in store
Chicken liver	Sweden or Denmark	2	0	2	0.8	Online trades
Cold cuts (ham and turkey)	2 products/sample	6	0	6	3	Nielsen IQ, online trades
Bacon	Sweden	4	0	4	2	Nielsen IQ
Smoked pork loin	Sweden or Germany	2	0	2	0.8	Nielsen IQ
Bologna/salami	1 product/sample	4	0	4	2	Nielsen IQ, online trades
Hotdogs	1 product/sample	17	0	17	9	Nielsen IQ, online trades
Falu sausage	1 product/sample	13	0	13	7	Nielsen IQ, online trades
Liver paste	1 product/sample	3	0	3	2	Nielsen IQ, online trades
Sausage, canned	1 product/sample	2	40	1	0.7	Nielsen IQ, online trades

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Meatballs and hamburgers, frozen	2 products/sample	10	0	10	5	Nielsen IQ, online trades
Dinner with meat (single serving), frozen	2 products/sample	12	0	12	6	Nielsen IQ, online trades
Total		**203**		**194**	**100**	
Subgroup: processed meat						
Cold cuts (ham and turkey)	2 products/sample	6	0	6	12	Nielsen IQ, online trades
Bacon	1 product/sample (2 batches/product)	4	0	4	8	Nielsen IQ
Smoked pork loin	1 product/sample	2	0	2	3	Nielsen IQ
Bologna/salami	1 product/sample (2-3 batches/product)	4	0	4	8	Nielsen IQ, online trades
Hotdogs	1 product/sample (2 batches/product)	17	0	17	35	Nielsen IQ, online trades
Falu sausage	1 product/sample (2 batches/product)	13	0	13	27	Nielsen IQ, online trades
Liver paste	1 product/sample	3	0	3	7	Nielsen IQ, online trades
Total		**48**		**48**	**100**	
Lean fish						
Cod, frozen	1 product/sample (2 batches/product)	4	0	4	26	Nielsen IQ
Pollock, frozen	1 product/sample	2	0	2	11	Nielsen IQ
Alaska pollock, frozen	1 product/sample	1	0	1	6	Nielsen IQ
Canned tuna in water	1 product/sample (2 batches/product)	1	0	1	9	Nielsen IQ, online trades
Fish sticks	1 product/sample	2	0	2	15	Online trades
Shrimp, North Sea, frozen	1 product/sample (2 batches/product)	4	0	4	23	Nielsen IQ
Shrimp, prepared or preserved	1 product/sample (2 batches/product)	2	0	2	11[4]	Nielsen IQ, online trades
Total		**15**		**15**	**100**	
Fatty fish						
Salmon, fresh	1 product/sample (2 batches/product)	4	0	4	25	Nielsen IQ, online trades
Salmon, frozen	1 product/sample (2 batches/product)	4	0	4	25	Nielsen IQ
Salmon, hot smoked	1 product/sample (1-2 batches/product)	1	0	1	6	Nielsen IQ, online trades
Salmon, cold smoked	1 product/sample	1	0	1	6	Nielsen IQ, online trades
Pickled herring	1 product/sample (2-7 batches/product)	5	0	5	28[5]	Nielsen IQ, online trades

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Herring	1 product/sample	0.3	0	0.3	2	Available in store
Mackerel in tomato sauce	1 product/sample	1	0	1	6	Nielsen IQ
Caviar	1 product/sample	1	0	1	4	Nielsen IQ
Total		**17**		**17**	**100**	
Meat substitutes						
Tofu	1 product/sample (1-2 batches/product)	0.4	0	0.4	14	Nielsen IQ or own brand product
Vegetarian deli	1 product/sample	0.1	0	0.1	2	Nielsen IQ, online trades
Frozen soy mince	2 products/sample	0.5	0	0.5	18	Online trades
Pieces/fillets (soy protein)	1 product/sample	0.4	0	0.4	12	Online trades
Vegetarian sausage (soy, pea, and/or bean protein)	1 product/sample	0.2	0	0.2	5	Online trades
Vegetarian burger (wheat, soy, and/or pea protein)	1 product/sample	0.5	0	0.5	16	Online trades
Schnitzel/nuggets (wheat or soy protein)	1 product/sample	0.4	0	0.4	13	Online trades
Plant-based meatballs (mycoprotein, wheat, and/or soy protein)	1 product/sample	0.3	0	0.3	10	Online trades
Falafel	1 product/sample	0.3	0	0.3	10	Online trades
Total		**3**		**3**	**100**	
Lean dairy products						
Milk 0.5% fat, conventional	2 products/sample	27	0	27	11	Nielsen IQ and own brand product
Milk 0.5% fat, organic	1 product/sample	6	0	6	2	Nielsen IQ or own brand product
Milk 1.5% fat, conventional	2 products/sample	74	0	74	30	Nielsen IQ and own brand product
Milk 1.5% fat, organic	1 product/sample	16	0	16	7	Nielsen IQ or own brand product
Milk 3% fat, conventional	2 products/sample	42	0	42	17	Nielsen IQ and own brand product

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Milk 3% fat, organic	1 product/sample	9	0	9	4	Nielsen IQ or own brand product
Sour milk 0.5% fat, plain	1 product/sample	4	0	4	1	Nielsen IQ, online trades
Yogurt 0.5% fat, plain	1 product/sample	2	0	2	0.7	Online trades
Yoghurt <0.5% fat, flavoured	1 product/sample	4	0	4	2	Nielsen IQ, online trades
Sour milk 1.5% fat, pain	1 product/sample	6	0	6	2	Nielsen IQ or own brand product
Yoghurt 2% fat, plain	1 product/sample	3	0	3	1	Online trades
yoghurt 2% fat, flavoured	1 product/sample	7	0	7	3	Nielsen IQ, online trades
Sour milk 3% fat, plain	1 product/sample	18	0	18	7	Nielsen IQ, online trades
Yoghurt 3% fat, plain	1 product/sample	9	0	9	4	Online trades
Yoghurt 2% fat, flavoured	1 product/sample	21	0	21	8	Nielsen IQ, online trades
Total		**249**		**249**	**100**	
Fatty dairy products						
Cooking cream	1 product/sample	7	0	7	11[6]	Online trades
Sour cream	1 product/sample	0.5	0	0.5	0.7	Nielsen IQ
Cooking yoghurt	1 product/sample	0.6	0	0.6	0.9	Nielsen IQ
Whip cream (36-40% fat)	1 product/sample	9	0	9	13	Nielsen IQ
Hard cheese ”Hushållsost”	1 product/sample (2 batches/product)	17	0	17	24	Nielsen IQ
Hard cheese ”Prästost”	1 product/sample (2 batches/product)	12	0	12	17	Nielsen IQ
Hard cheese ”Herrgårdsost”	1 product/sample	9	0	9	12	Nielsen IQ
Spreadable cheese	1 product/sample	3	0	3	4	Nielsen IQ
Halloumi	1 product/sample	3	0	3	5	Nielsen IQ or own brand product
Feta cheese	1 product/sample	1	0	1	2	Nielsen IQ, online trades
Dessert cheese	1 product/sample	2	0	2	3	Nielsen IQ, online trades
Cottage cheese	1 product/sample	6	0	6	8	Nielsen IQ
Total		**70**		**70**	**100**	
Plant-based drinks						

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Yoghurt	2 products/sample	2	0	2	12	Nielsen IQ, online trades
Cream products	1 product/sample	1	0	1	8	Online trades
Oat milk	3 products/sample	9	0	9	64	Online trades
Almond milk	1 product/sample	0.9	0	0.9	7	Online trades
Soy milk	2 products/sample	1	0	1	8	Online trades
Total		**13**		**13**	**100**	
Eggs						
Eggs, free-range indoor	1 product/sample (5-6 batches/product)	28	12	24	84	Nielsen IQ
Eggs, organic	1 product/sample (2-3 batches/product)	5	12	5	16	Online trades
Total		**33**		**29**	**100**	
Fats and oils						
Butter 80% fat	1 product/sample	8	0	8	14	Nielsen IQ or own brand product
Baking and cooking fat in foil	2 products/sample	2	0	2	4	GfK
Table margarine butter/oil, 75% fat	1 product/sample	8	0	8	15	Online trades
Table margarine, mainly vegetable, 70-75% fat	1 product/sample	2	0	2	4	GfK
Liquid margarine (mixture of butter and oil)	1 product/sample	4	0	4	6	Online trades
Light margarine, approx. 40% fat	2 products/sample	11	0	11	20	Online trades
Cooking oil	1 product/sample	1	0	1	1	Online trades
Canola oil	2 products/sample	3	0	3	5	Online trades
Olive oil	2 products/sample	1	0	1	2	Online trades
Mayonnaise	1 product/sample (2 batches/product)	9	0	9	16	Nielsen IQ, online trades
Bearnaise/hollandaise sauce	1 product/sample	3	0	3	5	Nielsen IQ, online trades
Salad dressing	1 product/sample	4	0	4	8	Nielsen IQ, online trades
Total		**55**		**55**	**100**	
Vegetables						

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Carrot, fresh	Sweden or Italy	23	5	22	9	Available in store
Carrot, fresh, organic	Sweden	4	5	4	2	Available in store
Beets, fresh	Sweden	4	17	4	1	Available in store
Cucumber, fresh	Sweden	17	8	16	6	Available in store
Yellow onion, fresh	Sweden or the Netherlands	25	6	24	10	Available in store
Leeks, fresh	Sweden or the Netherlands	2	8	2	0.8	Available in store
Cauliflower, fresh	Sweden	4	33	3	1	Available in store
Broccoli, fresh	Sweden or Spain	8	39	5	2	Available in store
Cabbage, fresh	Sweden	5	14	5	2	Available in store
Iceberg lettuce, fresh	Sweden	41	5	39	16	Available in store
Large tomatoes, fresh	The Netherlands	13	0	13	5	Available in store
Small tomatoes, fresh	The Netherlands, Morocco or Spain	13	0	13	5	Available in store
Mixed bell peppers, fresh	Yellow, red. The Netherlands or Spain	27	15	23	9	Available in store
Broccoli, frozen	1 product/sample	4	0	4	2	Online trades
Stir-fry vegetables, frozen	1 product/sample	4	0	4	1	Online trades
Peas, frozen	1 product/sample	3	0	3	1	Online trades
Mixed vegetables, frozen	1 product/sample	2	0	2	1	Online trades
Chopped spinach, frozen	1 product/sample	1	0	1	0.6	Online trades
Red lentils, dried	1 product/sample	1	0	1	0.5	Nielsen IQ
Pickled cucumber	1 product/sample	9	40	5	2	Nielsen IQ or own brand product
Crushed tomatoes	1 product/sample	23	0	23	9	Nielsen IQ or own brand product
Corn kernels, canned	1 product/sample	8	40	5	2	Nielsen IQ or own brand product
Olives, black	1 product/sample	3	40	2	0.6	Nielsen IQ, online trades
Olives, green	1 product/sample	3	40	2	0.6	Nielsen IQ, online trades
Ketchup	1 product/sample	20	0	20	8	Nielsen IQ, online trades
Total		**271**		**245**	**100**	

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Fruits						
Oranges, fresh	South Africa	20	29	14	7	Available in store
Clementines etc, fresh	South Africa, Peru or Spain	20	25	15	7	Available in store
Grapes, red, fresh	Italy or Spain	3	4	3	1	Available in store
Grapes, green, fresh	Greece or Italy	3	4	3	1	Available in store
Mixed nuts, snacks	1 product/sample	7	0	7	3	Nielsen IQ, online trades
Walnuts, unsalted	1 product/sample	0.8	0	0.8	0.4	Online trades
Almonds, unsalted	1 product/sample	0.8	0	0.8	0.4	Online trades
Apples, fresh	France or Italy	27	8	25	12	Available in store
Pears, fresh	The Netherlands	6	8	5	3	Available in store
Peach/nectarine, fresh	Spain or Italy	5	24	4	2	Available in store
Plume, fresh	Italy, Sweden or Hungary	1	6	1	0.6	Available in store
Bananas, fresh	Ecuador or Colombia	29	37	18	8	Available in store
Bananas, organic, fresh	Ecuador or Dominican Republic	29	37	18	8	Available in store
Avocado, fresh	Kenya or Peru	8	32	5	2	Available in store
Kiwi, fresh	Chile or New Zeeland	5	15	4	2	Available in store
Mango, fresh	Spain, Israel or Brazil	5	31	4	2	Available in store
Strawberries, fresh	Sweden	5	3	5	2	Available in store
Blueberries fresh	Argentine, Poland or Peru	2	2	2	1	Available in store
Raspberries, fresh	Poland or Portugal	2	0	2	1	Available in store
Strawberries, frozen	1 product/sample	1	0	1	0.5	Online trades
Blueberries, frozen	1 product/sample	0.5	0	0.5	0.2	Online trades
Raspberries, frozen	1 product/sample	2	0	2	1	Online trades
Raisins	1 product/sample	3	0	3	2	Nielsen IQ, online trades
Pineapple, canned	1 product/sample	6	40	4	2	Nielsen IQ, online trades
Fruit cocktail, canned	1 product/sample	1	40	0.7	0.3	Nielsen IQ, online trades
Peach, canned	1 product/sample	1	40	0.8	0.4	Nielsen IQ, online trades
Lingonberry jam	1 product/sample	8	0	8	4	Nielsen IQ, online trades

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Strawberry jam	1 product/sample	3	0	3	2	Nielsen IQ, online trades
Apple purée	1 product/sample	3	0	3	1	Nielsen IQ, online trades
Juice, not concentrate	1 product/sample	16	0	16	7	Nielsen IQ, online trades
Juice, concentrate	1 product/sample	1	0	1	0.5	Nielsen IQ, online trades
Fruit/berry drink, not concentrate	1 product/sample	9	0	9	4	Nielsen IQ, online trades
Fruit/berry drink, concentrate	1 product/sample	5	0	5	2	Nielsen IQ, online trades
Fruit cordial, concentrate	2 products/sample	21	0	21	10	Nielsen IQ, online trades
Total		**260**		**215**	**100**	
Potatoes						
Potatoes, peeled, organic	Sweden	5	20	4	3	Online trades
Potatoes, unpeeled, organic	Sweden	5	0	5	4	Online trades
Potatoes, peeled, conventional	Sweden	58	20	46	33	Online trades
Potatoes, unpeeled, conventional	Sweden	58	0	58	41	Online trades
French fries, frozen	1 product/sample	14	0	14	10	Nielsen IQ
Potato wedges, frozen	1 product/sample	9	0	9	7	Nielsen IQ
Potato chips	2 products/sample	6	0	6	4	Nielsen IQ, online trades
Total		**155**		**142**	**100**	
Sugar and sweets						
Granulated sugar	1 product/sample (2 batches/product)	12	0	12	17	Nielsen IQ or own brand product
Chocolate drink powder with sugar	1 product/sample	5	0	5	7	Nielsen IQ
Chocolate sauce for ice cream	1 product/sample	0.7	0	0.7	0.9	Online trades
Honey	1 product/sample	2	0	2	3	Nielsen IQ, online trades
Chocolate cookies	1 product/sample (2 batches/product)	7	0	7	9	Nielsen IQ or own brand product
Chocolate confectionery	1 product/sample (2-3 batches/product)	4	0	4	5	Nielsen IQ
Hazelnut spread	1 product/sample	9	0	9	12	Nielsen IQ

Product, Food	No. products/batches[1]	Consumption (g/person/day), incl. waste	Waste (%)	Consumption (g/person/day, excl. waste[2]	% of sample	Source for choice of products[3]
Sugar confectionery	2 products/sample (2-5 batches/product)	21	0	21	28	Nielsen IQ, online trades
Ice cream	1 product/sample	9	0	9	12	Nielsen IQ, online trades
Single-serving ice cream	1 product/sample (2 batches/product)	4	0	4	6	Nielsen IQ
Popsicle	1 product/sample	1	0	1	2	Online trades
Total		**74**		**74**	**100**	
Beverages						
Soda with sugar	2 products/sample (2 batches/product)	88	0	88	33	Nielsen IQ, online trades
Diet soda	2 products/sample	79	0	79	30	Nielsen IQ, online trades
Cider	1 product/sample	9	0	9	3	Oneline trades
Mineral water, flavoured	1 product/sample	31	0	31	12	Nielsen IQ, online trades
Non-carbonated fruit drink	1 product/sample	18	0	18	7	Nielsen IQ, online trades
Carbonated mineral water, plain	1 product/sample	4	0	4	2	Nielsen IQ
Still (non-carbonated) mineral water	1 product/sample	1	0	1	0.5	Nielsen IQ
Beer, <2.25% alcohol	1 product/sample	1	0	1	0.5	Nielsen IQ
Beer, non-alcoholic	1 product/sample	3	0	3	1	Nielsen IQ
Beer, 2.8% alcohol	2 products/sample	14	0	14	5	Nielsen IQ
Beer, 3.5% alcohol	2 products/sample	14	0	14	5	Nielsen IQ
Total		**262**		**262**	**100**	
Coffee and tea						
Coffee powder (medium roast and Arabic bean)	2 products/sample (3 batches/product)	316[7]	0	316[7]	78	Nielsen IQ, online trades
Black tea, loose tea	1 product/sample	36[8]	0	36[8]	9	Nielsen IQ, online trades
Black tea, bagged tea	1 product/sample	36[8]	0	36[8]	9	Nielsen IQ, online trades
Instant coffee	1 product/sample	19[7]	0	19[7]	5	Nielsen IQ, online trades
Total		**408**		**408**	**100**	

[1] Product is defined as a food item with a specific brand. If one brand made up for more than 15% of a sample, several batches of that brand was included. Other brands can also have several batches even if they constitute ≤15% of a sample because a larger amount of the product was needed in the sample.

[2] Corresponds to the per capita consumption used in the estimations of the per capita intake.

[3] References: Nielsen IQ (2018): https://www.Nielsen IQ.com/ [accessed 05 June 2023]. Growth for Knowledge (GfK) (2021): *GfK Panel Sverige* https://panel.gfk.com/scan-se/hem?srcid=23185&gclid=EAIaIQobChMIl_-K2MyS_wIVHI1oCR1HQg0wEAAYASAAEgIKYfD_BwE [accessed 26 May 2023]. Online trades were mainly for ICA, Coop, and Willys. Combined sources are often used.

[4] One sample contained slightly less shrimps than the other two samples (1.2 g instead of 1.6 g).

[5] One sample contained less pickled herring than the other two samples (2.7 g instead of 4.9 g).

[6] Two samples contained less cooking cream than one sample (6.2 g and 6.4 g instead of 7.4 g).

[7] Consumption converted to ready-to-drink by multiplying the data from Swedish Board of Agriculture with 15.

[8] Consumption converted to ready-to-drink by multiplying the data from Swedish Board of Agriculture with 100.

Appendix 2. Calculation of population mean body weight

Calculation of population mean body weight in Sweden when adjusting for weights in younger age groups are shown in Table A2.1. Population distribution is based on numbers derived from Statistics Sweden´s statistical database (Statistic´s Sweden, 2023) for population by age and sex in year 2022. Children mean weights are based on weight curves given in Nordic nutrition recommendations (Blomhoff et al., 2023). Adult mean weights are based on data from the Public Health Agency of Sweden´s survey “Hälsa på lika villkor 2022” (16 years or older) (Public Health Agency of Sweden, 2023) for adults 16 years or older.

Table A2.1. Estimation of population mean body weigh in Sweden when considering population distribution.

Age (yrs)	Men N	Men Proportion of population (%)	Men Mean weight (kg)	Women N	Women Proportion of population (%)	Women Mean weight (kg)	Contribution to population mean weight (kg)[1]
0	54 095	0.51	3.6	51 091	0.49	3.5	0.04
1	59 411	0.56	10.4	56 712	0.54	9.7	0.11
2	59 723	0.57	13.2	56 304	0.54	12.4	0.14
3	60 942	0.58	15.2	57 408	0.55	14.6	0.17
4	62 012	0.59	17.4	58 669	0.56	16.8	0.20
5	62 443	0.59	19.3	59 105	0.56	19	0.22
6	64 547	0.61	21.9	61 159	0.58	21.6	0.26
7	64 092	0.61	24.6	59 750	0.57	24	0.29
8	64 540	0.61	27.2	60 931	0.58	26.7	0.32
9	64 198	0.61	30.1	60 390	0.57	29.8	0.35
10	64 589	0.61	33.3	61 154	0.58	33.5	0.40
11	64 108	0.61	36.9	60 640	0.58	37.7	0.44
12	66 744	0.63	41.4	62 893	0.60	42.9	0.52
13	64 985	0.62	47	61 270	0.58	48	0.57
14	64 577	0.61	53.2	60 611	0.58	52.3	0.63
15	63 641	0.60	59.4	59 916	0.57	55.3	0.67
≥16	4 293 677	41	84.5	4 275 229	41	69.9	63
Sum							**68**

[1] Contribution to population mean weight for each age group was calculated by the following formula: $\%_{men\ (age\ group)}$*mean $weight_{men\ (age\ group)}$ + $\%_{females\ (age\ group)}$*mean $weight_{females\ (age\ group)}$

Appendix 3. Overview of samples per compound and food group

The table describes in which food groups each compound was analysed and the number of samples per food group and compound.

Chemical analysis	Cereal products	Pastries	Pizza, hand pie[1]	Meat	Processed meat[2]	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea	Total
Nutrients																				
Carotenoids	3	3						3	3	3	3	3	3	3	3	3	3			36
Essential minerals	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	57
Fatty acids	3	3		3	3	3	3	3	3	3	3	3	3	3	3	3	3			48
Fibres	3	3		3	3	3	3	3			3			3	3	3	3			36
Folate	3	3		3		3	3	3	3	3	3	3		3	3	3	3	3		45
Iodine	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	57
Macronutrients[3]	3	3		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3[4]	3[5]	54
Mono-/disaccharides	3	3		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		51
Retinols	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3		48
Riboflavin	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3		48
Thiamin	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3		48
Tocopherols	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3		48
Vitamin D	3	3		3		3	3	3	3	3	3	3	3				3			36
Vitamin K	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3			45
Water	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	57
Contaminants/ unwanted substances																				
Acrylamide	3	3	3					3								3	3	3	3	24
BFRs				3		3	3	3	3	3	3	3	3							27
Chlorinated paraffins[6]	1[6]	1[6]		1[6]		1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	1[6]	17

Chemical analysis	Cereal products	Pastries	Pizza, hand pie[1]	Meat	Processed meat[2]	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages	Coffee and tea	Total
Metals	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	57
Inorganic arsenic	3					3	3	3			3			3	3		3		3	27
3-MCPD, glycidol	3	3			3	3	3	3			3		3			3	3			30
Mycotoxins	3														3					6
Organochlorine pesticides				3		3	3	3	3	3	3	3	3							27
PAHs	3	3		3	3	3	3	3			3		3	3	3		3		3	39
PCBs/dioxins				3		3	3	3	3	3	3	3	3							27
PFAS	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3	3	51
PFRs	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3	3	51
Plasticizers	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3	3	51
Radionuclides[7]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
Total	74	68	16	68	31	74	74	80	65	65	77	65	68	62	65	62	71	47	35	1167

BFRs, brominated flame retardants; MCPD; PAHs, polycyclic aromatic hydrocarbons; PFAS, poly- and perfluorinated alkyl substances; PFRs, phosphorous flame retardants.

[1] Subgroup of Pastries.

[2] Subgroup of Meat.

[3] Ash, fat, nitrogen, starch.

[4] Only ash and starch.

[5] Only ash.

[6] A pooled sample was prepared for each food group. One third of each sample was mixed in the pool.

[7] The results will be presented in a separate report.

Appendix 4. Chemical analytical methods used in the Market Basket 2022

A 4.1 Macronutrients

Table A4.1.1 presents the methods used for determining the content of macronutrients in the Market Basket 2022. Measurement uncertainty and LOQ are also shown. All analyses were performed at accredited laboratories.

Total fat was analysed by Eurofins Food & Feed Testing Sweden in Linköping, Sweden, using nuclear magnetic resonance spectroscopy (NMR).

Individual fatty acids were analysed at the Swedish Food Agency in Uppsala, Sweden. Fatty acids were determined by gas chromatography using a modified method by IUPAC 6th Ed, Part 1, 2.301 and 2.302, 1979. Methyl esters of fatty acids were produced from triglycerides by metanolysis in an alkaline environment. The percentage proportion of a mixture of methyl esters of fatty acids were determined by gas chromatography. Individual fatty acids were not analysed if total fat content was less than 0.5 g/100 g (i.e. the food group vegetables). The sums of the percentage proportion of fatty acid groups were calculated by the following formulas:

SFA =	(4:0 + 6:0 + 8:0 + 10:0 + 11:0 + 12:0 + 13:0 + 14:0 + 14:0iso + 15:0 + 15:0anteiso + 15:0iso + 16:0 + 16:0anteiso + 16:0iso + 17:0 + 17:0anteiso + 17:0iso + 18:0 + 18:0anteiso + 18:0iso + 20:0 + 22:0 + 23:0 + 24:0)
MUFA =	(10:1 + 12:1 + 14:1 + 15:1 + 16:1 + 17:1 + 18:1 + 20:1 + 22:1 + 24:1n-9)
PUFA =	(16:2n-4 + 16:3 + n- 3 PUFA + (n-6 PUFA – 18:2n-6 + 18:2))
n-3 PUFA =	(16:4n-3 + 18:3n-3 + 18:4n-3 + 20:3n-3 + 20:4n-3 + 20:5n-3 + 21:5n-3 + 22:4n-3 + 22:5n-3 + 22:6n-3)
n-6 PUFA =	(18:2n-6 + 18:3n-6 + 20:2n-6 + 20:3n-6 + 20:4n-6 + 22:2n-6 + 22:4n-6 + 22:5n-6)
TFA =	(14:1trans + 16:1trans + 18:1trans + 20:1trans + 18:2trans + 18:3n-3trans)

Starch was analysed by Eurofins Food & Feed Testing Norway using polarimetry.

Dietary fibres were analysed by Eurofins Food Testing Netherlands (Heerenveen) (EUNLHE) using enzymatic gravimetric-high-performance liquid chromatography (HPLC). The analysis includes both high and low molecular weight fibres as well as resistant starch. Total fibre content was calculated as the sum of high molecular weight (water-insoluble polysaccharides and water-soluble polysaccharides) and low molecular weight fibre (oligosaccharides).

Mono- and disaccharides were analysed by Eurofins Food & Feed Testing Sweden in Linköping, Sweden, using HPLC.

Water and ash contents were analysed by Eurofins Food & Feed Testing Sweden in Linköping, Sweden, using gravimetry.

Protein was analysed as nitrogen by Kjeldahl et al by Eurofins Food & Feed Testing Sweden in Linköping, Sweden. The standard nitrogen conversion factor of 6.25 (Regulation (EU) No 1169/2011) was used for calculating protein content.

Table A4.1.1. Chemical methods, measurement uncertainty and limit of quantifications (LOQs) used for determining the content of macronutrients in the Market Basket 2022.

Substance	Method	Laboratory	Measurement uncertainty	LOQ
Fat, total[1]	NMKL 160 mod.	EUSELI	±10%	1 g/kg
Fatty acids (FA)	GC-FID (SLV-m062-f.9)	Swedish Food Agency	±34% if FA ≤0.5% ±7% if FA >0.5-6% ±5% if FA >6% ±10% total trans FAs	0.1%
Nitrogen (Kjeldahl)[2]	NMKL 6:2003	EUSELI	±10%	0.5 g/kg
Fibre, total	AOAC 2009.01-M	EUNLHE		
High molecular weight fibers + resistant starch[3]	AOAC 2009.01 (HEC1A)	EUNLHE	±18.5%	4 g/kg
Low molecular weight fibers[3]	AOAC 2009.01 (HEC1A)	EUNLHE	±15.4-22.0%	2 g/kg
Starch[4,5]	In-house method (MJ010 and MJ011)	EUNOMO2	±15%	10 g/kg
Glucose	AOAC 982.14, mod.	EUSELI	±15-25%	0.4 g/kg
Fructose	AOAC 982.14, mod.	EUSELI	±15-25%	0.4 g/kg
Saccharose	AOAC 982.14, mod.	EUSELI	±15-30%	0.4 g/kg
Lactose	AOAC 982.14, mod.	EUSELI	±15-25%	0.4 g/kg
Maltose	AOAC 982.14, mod.	EUSELI	±15-25%	0.4 g/kg
Galactose	AOAC 982.14, mod.	EUSELI	±25%	0.4 g/kg
Ash	NMKL 173	EUSELI	±10%	1 g/kg
Water[6]	NKML 23	EUSELI	±10%	1 g/kg

[1] Lean dairy products were analysed using the method ISO 1211/IDF 1:2010 according to Röse Gotlieb. Measurement uncertainty was ±8% and LOQ was 0.2 g/kg.

[2] Measurement uncertainty was ±20% for fats and oils.

[3] Modified AOAC 2009.1 was used for the food groups cereal products and pastries (AOAC2009.1 HEC4F) with the same measurement uncertainty and LOQ as AOAC 2009.01.

[4] Resistant starch is not included in the analysis.
[5] Starch analysis (MJ011) includes free glucose in the following food groups: meat, processed meat, lean and fatty fish, lean and fatty dairy products, egg, fats and oils with the same measurement uncertainty and LOQ as MJ010.
[6] Fats and oils were analysed according to Karl Fischer (ISO 8534:2017, measurement uncertainty: ±25%, LOQ: 1 g/kg). Lean and fatty dairy products were analysed using ISO 1358/IDF 151:2005 and ISO 5534/IDF 4:2004, respectively (dry substance) and with measurement uncertainty of ±10%.

A 4.2 Vitamins

Fat-soluble vitamins

The fat-soluble vitamins were analysed at the Swedish Food Agency. Methods and principles are presented in Table A4.2.1, along with measurement uncertainty and LOQ. In order to determine vitamin A in human diet, different analytical methods were required. One for provitamin A, carotenoids with vitamin A activity (β-carotene, α-carotene, and β-cryptoxanthin), in foods of plant origin, and one for preformed vitamin A (retinol and retinyl esters) in foods from animal sources. Carotenoids and retinols were determined using HPLC-DAD and HPLC-UV, respectively. The method used for retinol simultaneously determine vitamin E, but retinol was detected by UV and α-tocopherol with fluorescence (HPLC-FLD). With this method all tocopherols and tocotrienols could be determined. Vitamin K_1 (phylloquinone) and vitamin K_2 (menaquinone-4) were determined separately using HPLC-FLD, and the sum was reported as vitamin K. Menaquinone-7, menaquinone-8 and menaquinone-9 were determined in fatty dairy products, and, for menaquinone-9, also in lean dairy products and eggs (see Appendix 5, section A 5.2). Vitamin D was analysed by HPLC-UV. Vitamin D_3, (cholecalcipherol) was determined using vitamin D_2 (erogcalcipherol) as an internal standard. For one food group, plant-based drinks, vitamin D_2 was determined instead using vitamin D_3 as internal standard.

Water-soluble vitamins

The water-soluble vitamins were analysed by Eurofins Vitamin Testing in Denmark. The analytical methods, LOQ and measurement uncertainty are described in Table A4.2.1. The total amount of free thiamin and of free riboflavin were determined after dephosphorylation of phosphorylated forms using HPLC. Total amount of folate was determined by a microbiological assay after deconjugation of glutamate residues in natural forms of the vitamin.

Table A4.2.1. Chemical methods, measurement uncertainty and limit of quantification (LOQ), used for determining the content of vitamins in the Market Basket 2022.

Vitamin/Substance	Method reference	Method description	Measurement uncertainty	LOQ
Vitamin A (all-trans-retinol)	SLV-m049-f Determination of vitamin A in foods by HPLC-UV	Ascorbic acid added as antioxidant. Saponification with KOH for 30 min at 95 °C. Extraction with cyclohexane using a separatory funnel. HPLC: Amino column, 250 × 4.6 mm, 3 µm particles. Mobile phase: 3% isopropanol in n-heptane. UV detection, 325 nm.	± 9-18%	6 ug/100g
Vitamin A (β-carotene, α -carotene, β-cryptoxanthin)	SLV-m138-f Determination of carotenoids in foods by HPLC-DAD	Extraction in ethanol, hydrolyzation and thereafter addition with tetrahydrofuran. After neutralization of pH with phosphoric acid, renewed extraction followed by evaporation of the organic phase to suitable volume. Separation by reversed phase HPLC and detection by diode-array-detector.	± 12-18%	5 ug/100g
Vitamin D (D_3 cholecalciferol, D_2 erogcalciferol)	SLV-m061-f Determination of vitamin D_3 and vitamin D_2 respectively in foods by HPLC-UV	Ascorbic acid added as antioxidant. Vitamin D2 added as internal standard. Saponification with KOH for 30 min at 95 °C. Extraction with n-heptane. Sample clean-up with semi-preparative HPLC (silica). Reversed phase HPLC (C18), 250 × 4.6 mm, 5 µm particles. Mobile phase: 20% methanol in acetonitrile. UV detection, 265 nm.	± 7-14%	0.3 ug/100g
Vitamin E (α-tocopherol)	SLV-m049-f Determination of vitamin E in foods by HPLC and fluorescence detection	Ascorbic acid added as antioxidant. Saponification with KOH for 30 min at 95 °C. Extraction with cyclohexane using a separatory funnel. HPLC: Amino column, 250 × 4.6 mm, 3 µm particles. Mobile phase: 3% isopropanol in n-heptane. Fluorescence detection, λex 295 nm, λem 327 nm.	± 8-18%	0.013 mg/100g
Vitamin K (K_1 phylloquinone K_2 menaquinone-4)	SLV-m057-f Determination of vitamin K in foods by HPLC and fluorescence detection	Sample is mixed with 70 % ethanol after addition of internal standard. Extraction of fat-soluble components to heptane by reflux and extract is then evaporated to suitable volume. Separation on reversed phase HPLC column followed by reduction on a zinc powder column. Detection by fluorescence λex 248 nm, λem 418 nm.	± 9-16%	1 ug/100g
Thiamin Thiamin HCl	DJ074 In-house modified version of standard EN14122 Foodstuffs - Determination of vitamin B1 by HPLC	Vitamin B1 is extracted from the sample in an autoclave by acid hydrolysis. After dephosphorylation of phosphorylated forms, quantified by reversed phase-HPLC with fluorometric detection λex 368 nm, λem 440 nm after post-column oxidation to thiochrome. Result is reported as mg thiamin hydrochloride/100 g (= thiamin x 1,27)	± 16%	0.018 mg/100g

Vitamin/Substance	Method reference	Method description	Measurement uncertainty	LOQ
Riboflavin	DJB33 In-house modified version of standard EN14152 Foodstuffs - Determination of vitamin B2 by HPLC	Vitamin B2 is extracted from the sample in an autoclave by acid hydrolysis. After dephosphorylation of phosphorylated forms, quantified by reversed phase-HPLC with fluorometric detection.	± 16%	0,010 mg/100g
Folate	A7286 In-house modified version of previous NMKL standard 111:1985 Determination of folic acid by microbiological assay in milk	Folate (including folic acid) is extracted from the sample in an autoclave using a buffer solution, followed by an enzymatic digestion with human plasma and pancreas V and finally by a second autoclave treatment. After dilution with basal medium containing all required growth nutrients except folic acid the growth response of *Lactobacillus rhamnosus* (ATCC 7469) to extracted folate is measured turbidimetrically and is compared to calibration solutions with known concentrations.	± 30%	5 ug/100g

A 4.3 Minerals

Essential elements, excluding iodine

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 (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 15%. 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.

Iodine

Iodine concentrations were analysed by SGS Analytics in Jena, Germany, using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). SGS Analytics is an accredited laboratory. Limits of quantification was 10 µg/kg for both solid and liquid samples. Measurement uncertainty for iodine was approximately 20%.

A 4.4 Metals

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.

Inorganic arsenic

The analysis of inorganic arsenic was performed by HPLC-ICP-MS (high performance liquid chromatography – inductively coupled plasma mass spectrometry) at the Swedish Food Agency. 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 based on the European standard EN 16802:2016 and is accredited in accordance with ISO/IEC 17025 by SWEDAC for inorganic arsenic in food within the range 1-25 000 µg/kg. The limit of detection (LOD) was between 0.4 and 3 µg iAs/kg depending on the dilution of the sample before analysis, and the measurement uncertainty was +/- 19 %.

A 4.5 PCBs and dioxins

The analysis of PCBs and PCDD/Fs was performed at the Swedish Food Agency (SFA), Sweden. The 17 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 lean dairy products and plant-based drinks were treated with 2 ml potassium oxalate (35 % in water) and then liquid-liquid extracted using ethanol (100 ml) diethyl ether (50 ml) and n-pentane (120 ml).

Solid food groups were extracted by pressurized liquid extraction (PLE) using a system from Fluid Management Systems (MA, USA). Ethanol and toluene (7:3) were used for the extraction of meat, lean fish and meat substitutes. The other matrices were extracted with n-pentane and acetone (7:3). Two extraction cycles of 20 minutes each, with temperature 100°C and the pressure 1500 psi, were applied. The extracts were dried using dried sodium sulphate, followed by evaporation of the solvent and gravimetric lipid weight determination. Samples extracted with ethanol:toluen were further cleaned up using methyl-tert-butyl-ether (MTBE) before the lipid determination. Lipid removal, clean-up and fractionations were performed with a GO-2HT from Miura. The system uses four serially coupled liquid chromatography (LC) columns, a silver-nitrate column, a sulphuric-acid, a carbon and finally an alumina column.

Final determination was performed with gas chromatography and high-resolution mass spectrometry (GC-HRMS) (Thermo Trace 1300 GC and Thermo DFS Magnetic Sector instrument) using isotopic dilution technique. The ndl-PCBs were injected on a HT8 column with a split/splitless injector in splitless mode. The dl-PCBs and PCDD/Fs were injected on a Rtx-Dioxin2 column with a programmed temperature vaporizer (PTV) injector in solvent vent mode. CB 123 was quantified on the HT8 column. The HRMS was operated in electron ionization (EI) mode, using single ion monitoring (SIM) at the resolution of 10 000. The limit of quantification (LOQ), defined as signal-to-noise ratio (S/N)=3, was determined for all individual congeners in each sample.

13C-labelled surrogate standards for all analysed congeners were added to the samples prior to extraction. Control and blank samples were analysed together with the samples in every series 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 according to ISO/IEC 17025 for the analysis of PCDD/Fs and PCBs in milk, dairy products, fats, fish, meat, eggs, baby food, spices, whey protein powder and blood serum.

A 4.6 Organochlorine pesticides

The chemical analyses were performed at the Swedish Food Agency during spring 2024 according to a previously described analytical method (Tornkvist et al., 2011, Swedish Food Agency, 2017). Analysed compounds included HCB, HCHs (α-, β-, γ-HCH), chlordanes (α-, γ-chlordane, oxychlordane, trans-nonachlor) and DDT-analogues and their metabolites (o,p'-DDT, p,p'-DDT, p,p'-DDE and p,p'-DDD).

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).

All glassware was heated at 450°C over night 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 accuracy and precision of the measurements. LOQ varied depending on the matrix and the quantified analyte, ranging from 4 to 66 ng/kg fresh weight. The measurement uncertainty of the analytical method is between 20 and 40%. The method is accredited against ISO 17025 by SWEDAC for PCB and organochlorine pesticides in fish, milk and egg. The trueness of the method is proven by participating in proficiency tests.

A 4.7 Brominated flame retardants (BFRs)

The analyses were performed at the Swedish Food Agency during spring 2024 according to an analytical method described earlier (Swedish Food Agency, 2017, Tornkvist et al., 2011) with small modifications. Analysed compounds included nine PBDE congeners (BDE-28, -47, -66, -99, -100, -153, -154, -183, -209) and HBCDD.

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. 13C-BDE-155 and 13C-BDE-209 were used as internal standards and added to the samples before extraction. PBDEs and HBCDD were measured by gas chromatography/mass spectrometry (Agilent 5975) in negative ion chemical ionization mode (GC/MS NCI).

All glassware was heated at 450°C over night 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. The trueness of the method has also been proven by participating in proficiency tests. The laboratory is accredited according to ISO 17025 by SWEDAC for the analysis of fish/fish products, milk and eggs.

Reported results were corrected for levels found in blank samples. Estimated LOQs were set to either six times the standard deviation of the blank value or to the lowest standard concentration, the highest of them was chosen. The LOQ varied between 0.4 and 46 ng/kg fresh weight, depending on the analyte. Highest LOQ was determined for BDE-209, due to its complexity. The measurement uncertainty of the analytical method is between 10-55%.

A 4.8 Per- and polyfluoroalkyl substances (PFAS)

Sample preparation

A portion of homogenized sample (see Table A4.8.1 for sample amount for each food group) was used for the analysis. Two different extraction methods (solid-liquid extraction or solid phase extraction) were used depending on food group indicated in Table A4.8.1.

Table A4.8.1. Sample amount and extraction method used.

Matrix	Amount (g or mL)	Extraction method
Cereal products	1	solid-liquid
Pastries	1	solid-liquid
Eggs	1	solid-liquid
Meat	1	solid-liquid
Plant-based drinks	20	solid phase
Lean dairy products	1	solid-liquid
Fatty dairy products	1	solid-liquid
Fish	1	solid-liquid
Fats and oil	1	solid-liquid
Potatoes	1	solid-liquid
Fruits	1	solid-liquid
Vegetables	1	solid-liquid
Sugars and sweets	1	solid-liquid
Meat substitutes	1	solid-liquid
Beverages, coffee/tea	20	solid phase

For solid food group, solid-liquid extraction with Envi-Carb clean-up was used. In brief, a portion of homogenized sample was weighed into a 15 mL polypropylene tube and then spiked with 1 ng (10 µL) of mass labelled internal standard solution; details of the suite of mass labelled internal standards in the solution mix are provided in Table A4.8.3. Five mL of acetonitrile was added to the PP tube, and the sample was first vortexed followed with ultrasonicated for 15 min, then shaken on a horizontal shaker for 20 min at 250 rpm. After that, the sample was centrifuge at 8500 rpm for 10 min. The supernatant was then transferred to a new PP tube. Another 5 mL of acetonitrile was added to the original PP tube and the procedures of ultrasonication/shaking/centrifuge as described above was repeated once. The supernatant after centrifugation was transferred to the PP tube after the first extraction cycle. The combined acetonitrile was evaporated using a Rapidvap to below 1 mL. An approximate

100 mg of Envi-Carb was added to a new PP tube. The 1 mL acetonitrile was transferred to the PP tube containing Envi-Carb. A 0.5 mL of acetonitrile was added to the original PP tube to rinse out any PFAS that may have attached to the wall of the PP tube and was transferred to the 1 mL acetonitrile. This procedure was repeated once. The 2 mL of acetonitrile, together with Envi-Carb, was first vortexed, then ultrasonicated for 10 min, and finally centrifuged at 8500 rpm for 10 min. The supernatant was transferred to another new PP tube. Another 1 mL of acetonitrile was added to the PP tube containing Envi-Carb; the procedures of ultrasonication/centrifugation as shown above was repeated once. The supernatant was transferred to the 2 mL acetonitrile and evaporated under a gentle stream of nitrogen below 0.5 mL. Mass labelled recovery standards (1 ng, 10 µL) was added to the PP tube (Table A4.8.3); the final volume was adjusted to 0.5 mL with acetonitrile. Sample extract of 0.25 mL was transferred into a LC vial and was further evaporated down to 80 µL. After that, a 120 µL of aqueous mobile phase was added to the LC vial for instrumental analysis.

As for liquid samples, solid phase extraction using mixed modes of weak anion exchange cartridge (OASIS, WAX-SPE, 150 mg, 6 mL, Waters) was employed. In brief, aliquot of the liquid samples was first vortexed and then poured into a 50 mL PP tube; the samples were then spiked with mass labelled internal standards (1 ng, 10 µL). Then, 20 mL of ultrapure water was added to the sample. The pH of the diluted samples was adjusted to pH 4 using glacial acetic acid before loading on the SPE cartridge. The WAX SPE cartridge was first conditioned with a passage of a series of solution, which included 4 mL of 0.1% ammonium hydroxide solution in methanol, 4 mL of methanol, and 4 mL of ultrapure water. The diluted liquid samples were then loaded onto the cartridges. After sample loading, the cartridges were washed with the following solvents: 10 mL of ultrapure water, 4 mL of 25 mM ammonium acetate solution at pH 4 and 4 mL of 20% methanol in ultrapure water. All cartridges were dried for an hour using a vacuum pump connected to the manifold. To avoid possible losses of compounds that may attached to the wall of the container, the 50 mL PP tube was rinsed with 4 mL of 0.1% methanol. This 0.1% ammonium hydroxide in methanol was then used for elution and collected in a 15 mL PP tube. The 4 mL of the 0.1% ammonium hydroxide in methanol was then evaporated under a gentle stream of nitrogen to below 0.5 mL. Mass labelled recovery standards (1 ng, 10 µL) was added to the PP tube; the extract (0.25 mL) was then transferred to LC vial and further evaporated to 80 µL. After that, a 120 µL of aqueous mobile phase was added to the LC vial for instrumental analysis.

Instrumental analysis and quantification

An Acquity UPLC system (Waters) equipped with a BEH C18 (100 × 2.1 mm, 1.7 µm particle size, Waters) analytical column was used for all instrumental analyses. Mobile phase A was composed of 2 mM ammonium acetate with the composition of 70% ultrapure water and 30% methanol, while mobile phase B was composed of 2 mM ammonium acetate in methanol at a flowrate of 0.3 mL/min. Table A4.8.2 shows the mobile phases and gradient programme for the analysis. The injection volume was 10 µL and the column temperature was set to 50°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 400°C, respectively, and the desolvation and cone gas flows were set to 800 L/h and 150 L/h, respectively. The capillary voltage was set to 0.7 kV. Optimized cone-voltages and collision energies for each compound are provided in Table A4.8.3. Multiple reaction monitoring (MRM) was used to improve selectivity, and at least two transitions were monitored for most analytes.

Table A4.8.2. The mobile phases and gradient programme for the analysis.

T (min)	Mobile phase A (%)	Mobile phase B (%)
0.00	99	1
0.57	99	1
13.00	0	100
14.00	0	100
14.20	99	1
17.00	99	1

Table A4.8.3. Target compounds and selected instrumental parameters for quantification of each compound by UPLC/ESI-MS/MS.

Analyte	Precursor/ Daughter Ion I (m/z)	Collision Energy (eV)	Cone Voltage (V)	Precursor/ Daughter Ion II (m/z)	Collision Energy (eV)	Cone Voltage (V)	Corresponding mass labelled internal standard	Corresponding mass labelled recovery standard
Perfluoroalkyl carboxylic acids (PFCA								
PFHxA	312.97/269.00	9	20	312.97/118.95	26	20	$^{13}C_2$ PFHxA	$^{13}C_5$ PFHxA
PFHpA	362.97/319.00	10	20	362.97/168.97	16	20	$^{13}C_4$ PFHpA	$^{13}C_8$ PFOA
PFOA	412.97/369.00	10	20	412.97/168.97	18	20	$^{13}C_4$ PFOA	$^{13}C_8$ PFOA
PFNA	462.99/419.00	12	20	462.99/219.00	18	20	$^{13}C_5$ PFNA	$^{13}C_9$ PFNA
PFDA	512.97/469.00	11	20	512.97/219.00	18	20	$^{13}C_2$ PFDA	$^{13}C_6$ PFDA
PFUnDA	562.97/519.00	12	20	562.97/268.99	18	20	$^{13}C_2$ PFUnDA	$^{13}C_7$ PFUnDA
PFDoDA	612.97/569.00	14	34	612.97/168.97	22	40	$^{13}C_2$ PFDoDA	$^{13}C_7$ PFUnDA
PFTrDA	662.90/619.00	14	20	662.90/168.97	26	20	$^{13}C_2$ PFDoDA	$^{13}C_7$ PFUnDA
PFTDA	712.90/669.00	14	20	712.90/168.97	28	20	$^{13}C_2$ PFTDA	$^{13}C_7$ PFUnDA
Perfluorosulfonic acids (PFSA)								
PFBS	298.90/79.96	26	20	298.90/98.90	26	20	$^{13}C_3$ PFBS	$^{18}O_2$ PFHxS
PFHxS	398.90/79.96	34	20	398.90/98.90	30	20	$^{18}O_3$ PFHxS	$^{18}O_2$ PFHxS
PFOS	498.97/79.96	44	20	498.97/98.90	38	20	$^{13}C_4$ PFOS	$^{13}C_8$ PFOS
PFDS	598.97/79.96	58	20	598.97/98.90	42	20	$^{13}C_4$ PFOS	$^{13}C_8$ PFOS
Perfluoroalkane sulfonamide (FOSA)								
FOSA	497.90/78.00	30	82	497.90/168.96	28	82	$^{13}C_8$ FOSA	$^{13}C_8$ PFOS

Quality assurance and quality control measures

Accuracy and precision were evaluated by spiking native compounds (1 ng) into each matrix (Table A4.8.4) in triplicate. Two procedural blanks and two in-house QC sample (fish) were analyzed alongside the samples in each batch. All samples were spiked with mass labelled internal standards before extraction and the recoveries were evaluated with the mass labelled recovery standards, except for PFBS, PFDS, PFDoDA, PFTriDA, FOSA. For most of the compounds, exact matched mass labelled standards were available with the exception of PFDS, PFTriDA that surrogate mass labelled internal standards were used. Overall, native spiked recoveries were between 58-122% with the precision at most 14% of the relative standard deviation. Recoveries of matched mass labelled internal and recovery standards ranged from 50 and 127%. Internal calibration method with corresponding mass labelled internal standards was used. Instrumental limit of quantifications (ILOQs) were estimated based on the lowest point of calibration on a series of 6-point calibration curve producing a signal-to-noise ratio of 10 that resulted in an accurate measurement with uncertainty level < 20%. Limits of quantification (LOQs) were based on levels on procedure blanks and concentration factor. When no detectable blanks were observed in procedure blanks, LOQs would be the ILOQs after taking into consideration of concentration factor for most of the compounds (Table A4.8.5).

Table A4.8.4. Matrix spike recovery (%) and repeatability (%) results.

		PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTDA	PFBS	PFHxS	PFOS	PFDS	FOSA
Cereal products	Relative standard deviation (%)	3	4	7	6	7	9	12	9	12	2	9	7	6	10
	Recovery (%)	101	97	102	103	103	106	96	92	103	85	85	103	78	72
Pastries	Relative standard deviation (%)	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Recovery (%)	122	112	115	114	108	105	106	97	113	122	119	108	100	93
Eggs	Relative standard deviation (%)	6	11	2	3	4	3	2	5	2	6	1	6	6	2
	Recovery (%)	105	86	112	103	96	91	83	85	82	91	96	100	105	63
Meat	Relative standard deviation (%)	17	6	16	12	1	3	3	5	2	1	12	15	10	2
	Recovery (%)	91	73	98	92	82	79	73	74	66	88	90	101	95	63
Plant-based drinks	Relative standard deviation (%)	3	8	7	4	3	4	3	7	3	1	5	1	3	10
	Recovery (%)	107	94	107	107	105	105	71	77	77	104	106	110	102	90
Lean dairy products	Relative standard deviation (%)	2	2	2	2	1	1	3	1	1	3	2	2	2	5
	Recovery (%)	75	71	83	86	88	81	74	72	74	87	75	91	69	66
Fatty dairy products	Relative standard deviation (%)	11	5	2	17	6	2	3	2	2	2	11	3	3	3
	Recovery (%)	82	88	85	97	85	75	74	66	74	87	82	85	70	66
Fish	Relative standard deviation (%)	13	7	6	10	22	6	11	18	6	4	8	13	10	18
	Recovery (%)	99	103	99	101	110	105	96	92	98	89	100	100	97	97
Fats and oil	Relative standard deviation (%)	6	4	2	2	4	2	4	4	3	6	2	3	5	3
	Recovery (%)	84	80	87	87	87	88	83	87	79	114	87	92	89	67
Potatoes	Relative standard deviation (%)	6	7	9	11	13	18	2	3	4	11	5	1	6	4
	Recovery (%)	105	81	105	103	98	86	75	72	74	115	100	98	91	74
Fruits	Relative standard deviation (%)	4	4	5	3	2	1	1	5	4	6	3	8	5	2
	Recovery (%)	106	89	104	97	101	98	98	90	77	85	100	104	90	65
Vegetables	Relative standard deviation (%)	6	6	5	4	6	7	9	5	4	3	2	8	6	2
	Recovery (%)	92	84	92	97	95	95	83	82	84	98	96	102	90	62
Sugars and sweets	Relative standard deviation (%)	13	8	9	7	9	11	3	5	7	1	7	7	4	3
	Recovery (%)	84	81	93	86	89	86	77	82	82	58	89	86	82	87
Meat substitutes	Relative standard deviation (%)	3	3	5	1	8	3	2	5	5	4	3	8	8	3
	Recovery (%)	62	65	89	88	79	82	71	77	71	80	62	87	64	66
Beverage	Relative standard deviation (%)	6	6	5	4	3	7	3	1	5	1	4	3	6	10
	Recovery (%)	96	84	95	95	93	94	63	69	68	92	94	98	91	80

Table A4.8.5. Recovery and repeatability of QC-spike sample over the course of analysis.

		PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTDA	PFBS	PFHxS	PFOS	PFDS	FOSA
Fish QC spike	Relative standard deviation (%)	13	7	6	10	22	6	11	18	6	4	8	13	10	18
n=27 over 9 batches	Recovery (%)	99	103	99	91	91	85	86	72	78	89	100	100	97	70

A 4.9 Chlorinated paraffins (PCAs)

The sample preparation method was adapted from previous studies (Jensen et al., 2009) (Swedish Food Agency, 2017) and an overview of the process is depicted in Figure 43. Briefly, mass amount (or volume) equivalent to 0.3 g fat were weighted and spiked with 10 ng of $^{13}C_{10}$-1,5,5,6,6,10-hexachlorodecane as internal standard. Samples were then extracted by different organic solvent mixtures based on the nature of the food item (see Figure 43). Solid samples were homogenized using a bead mill by two cycles of 30 seconds in 14 mL hexane: acetone, 14:35. The samples were then extracted by two solid-liquid extraction cycles with 10 mL hexane: diethyl ether, 9:1. The liquid diary samples (previously dissolved in 6 mL hexane: acetone, 3:1), liquid samples, and sweets were extracted by two liquid-liquid extraction cycle with 6 mL hexane: acetone, 3:1 and one cycle with 10 mL hexane: diethyl ether, 9:1. Following, the supernatants of the solid samples and the liquid diary samples were dehydrated with 10 mL of aqueous 0.9% sodium chloride and 0.1 M phosphoric acid and extracted by two liquid-liquid extraction cycle with 5 mL hexane. Finally, all sample extracts were concentrated to 1 mL prior to the clean-up step. For the clean-up, a multilayer column packed with 2 g silica (deactivated with 2.5% H_2O), 6 g 44% sulfuric acid silica and 4 g of anhydrous sodium sulfate from bottom to the top was used. The concentrated extracts were loaded onto the column and then eluted by 15 mL of hexane/diethyl ether (1:1, v/v). The eluent was concentrated, and 10 ng $^{13}C_{12}$-1,1,1,3,10,12,12-octachlorododecane was spiked as recovery standard. The extracts were solvent exchanged to acetonitrile prior to instrumental analysis.

PCAs were measured using liquid chromatography coupled with quadrupole time-of-flight (LC qToF, Agilent 6546) in electrospray negative ionization mode. For the quantification of PCAs-$C_{10-30}Cl_{3-15}$ the [M+Cl]- ions were used. These adducts were generated by adding 0.01 M of tetramethylammonium chloride to the mobile phases. The contribution of each PCA homologue group, after blank subtraction, was calculated based on the deconvolution method proposed by Bogdal et al. (2015). For the pattern-deconvolution algorithm of PCA-C_{10-13} and PCA-C_{14-17} the single-chain standards (Chiron AS) C10 (52.5% and 58.4% Cl), C11 (52.3% and 57.7% Cl), C12 (53,8% and 57,3% Cl) and C13 (45,9% and 60% Cl), and C14 (49.2% and 58.7% Cl), C15 (47.7% and 59.3% Cl), C16 (51.5% and 58.4% Cl) and C17 (56.3% Cl) were used, respectively. For the analysis of PCA-C_{18-30} the standard mixtures from Dr. Ehrenstorfer (Augsburg, Germany) containing 36.0% Cl and 49.0% Cl, and the technical mixtures Uniclor40 from Neville Chemical Co (USA) and Paroil® CW 40 from Dover Chemical Corporation (USA) were used.

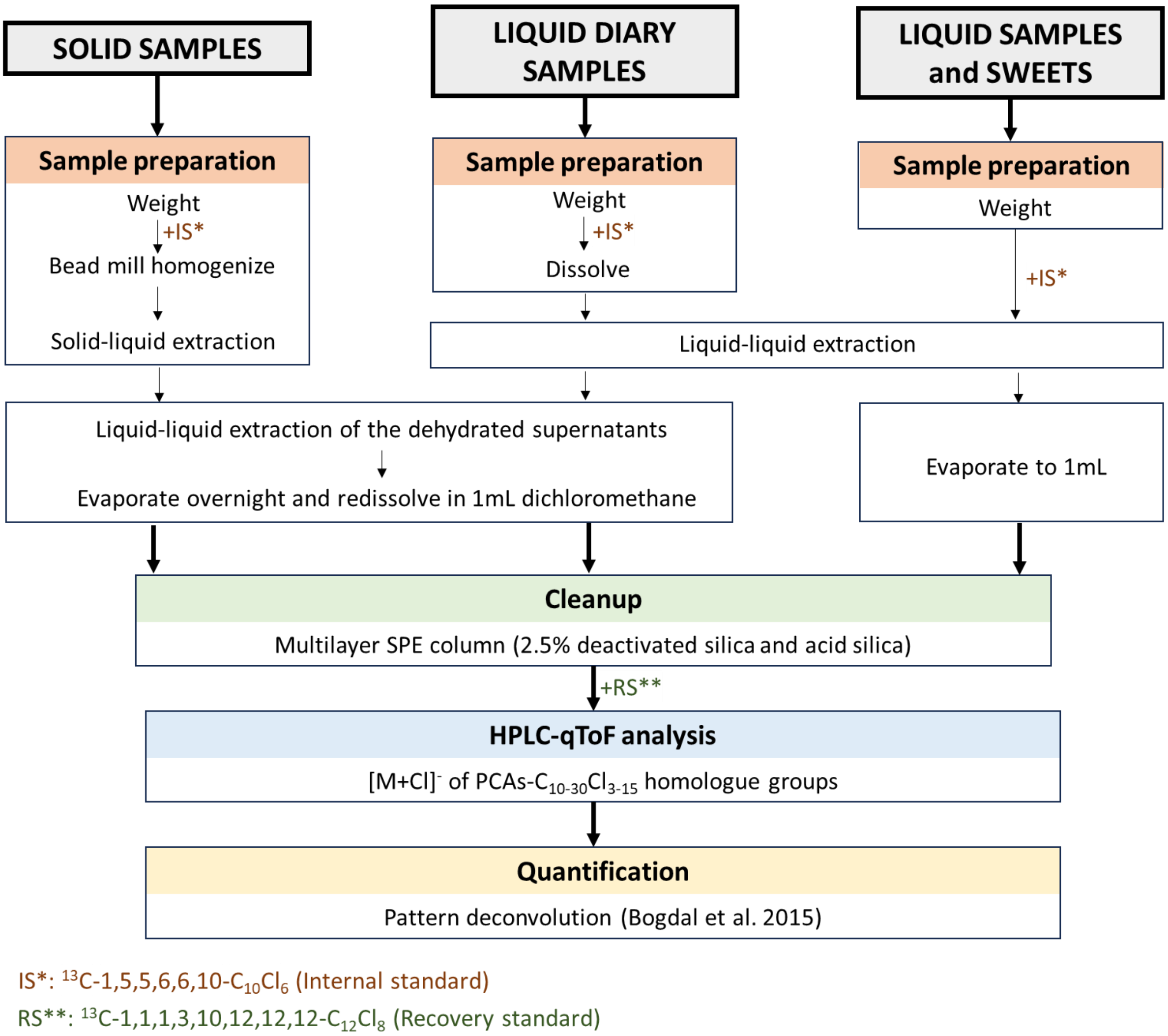

Figure 43. Method overview of polychlorinated alkane analysis

A 4.10 Organophosphate flame retardants (PFRs) and plasticizers

Sample preparation was done as described in Poma et al. (2019). Briefly, 0.10-0.15 g of each sample was spiked with internal standards for PFRs and plasticizers and extracted twice with ACN:toluene (9:1 v/v). Supernatant was evaporated until approximately 2 mL and dispersive solid phase extraction (d-SPE) was performed by adding 100 mg C18 and 50 mg primary-secondary amine to each sample. After vortexing and centrifuging supernatant was transferred, evaporated until dryness and reconstituted with 1 mL n-hexane. Samples were loaded onto Florisil cartridges (precleaned with 4 mL acetone, 6 mL ethyl acetate and 6 mL hexane). The analytes of interest were eluted with 10 mL ethyl acetate, evaporated until 4-5 mL, followed by an additional elution with 8 mL acetone. This elution fraction was evaporated until near dryness and reconstituted in recovery standard and methanol. Samples were filtered using 0.2 µm nylon filters and 15 µL of sample was transferred to an injection vial to which 135 µL ethyl acetate was added for analysis on the GC. The rest of the sample was transferred to a separate vial for LC analysis.

LC-MS/MS analysis was performed using an Agilent 1200 Infinity Liquid Chromatography System coupled to an Agilent 6410 Triple Quadrupole Mass Spectrometer in positive electrospray ionization mode. A Kinetex Biphenyl column (100 x 2.1 mm, 2.6 µm) was used at 40˚C to achieve separation. Mobile phase A consisted of ultrapure water with 5 mM ammonium formate, mobile phase B consisted of methanol with 5 mM ammonium formate. Bis(2-ethylhexyl) phthalate (DEHP) and bis (2-ethylhexyl) terephthalate (DEHT) were analysed on the GC using an Agilent GC (Agilent Technologies, Santa Clara, CA, USA) coupled to an Agilent 5973 MS operated in electron ionization mode. A GC HT-8 column (25 mm x 0.22 mm, 0.25 µm) and a programmable-temperature vaporizer inlet were used. The carrier gas was helium. The analytical method was validated and reported in detail in Christia et al. (Christia et al., 2019b).

A 4.11 Acrylamide

Analysis of acrylamide was performed by a method developed by the Swedish Food Agency (Rosén et al. 2007). The method is approved as a ”standard method” by the European Committee for Standardization (CEN).

For solid samples acrylamide is extracted from the mixed food items by shaking 4 grams of the homogenized food with 40 mL water for 60 minutes followed by centrifugation at 3600g for 10 minutes at 10°C. The extract (10 mL) is further cleaned-up using solid phase extraction in two steps. First, an Isolute multimode column (1 g) is used as a chemical filter, and in the second step an ENV+ column (500 mg) is used, where acrylamide is eluted with 60% methanol. The eluate is concentrated by evaporation to a final volume of 0.4-0-8 mL. Carbon-13 labelled acrylamide is used as an internal standard throughout the whole procedure. For coffee 40 ml of brewed coffee was centrifuged, and 5 ml of the supernatant used for further clean-up.

The analysis is performed by liquid chromatography, UHPLC (Waters Acquity I-class) coupled to tandem mass spectrometry, MS/MS (Waters Xevo TQ-S). The separation is performed by injection of 10 µL of the concentrated eluate on the analytical column Hypercarb, 5 µm, 100x2.1 mm (Hypersil-Keystone) using a mobile phase consisting of acetic acid (0.1%) running at isocratic mode at 0.4 mL/min. The MS was running in positive mode (ESI+), with a source temperature of 150°C and the desolvation temperature at 300°C. The m/z and energies are shown below in Table 1. The LOQ was determined to 5 µg/kg.

Table A4.11.1. MS parameters for the analysis of acrylamide.

Analyte	Precursor ion (m/z)	Product ion (m/z)	Cone voltage (V)	Collission energy (V)	Retention time Ca (min)
Acrylamide (Q)[1]	72.1	55.1	20	10	2.6-2.8
Acrylamide	72.1	54.1	20	7	2.6-2.8
Acrylamide	72.1	44.1	20	10	2.6-2.8
IS $^{13}C_3$-labelled Acrylamide (Q)[a]	72.1	58.1	20	10	2.6-2.8

[1] The transitions marked with a Q are used for quantification.

A 4.12 Glycidol, 2-MCPD and 3-MCPD

The samples were analysed at the accredited laboratory SGS Analytics SGS Laboratory (Hamburg, Germany).

The laboratory meets the quality criteria in the European Commission's recommendation (Commission recommendation 2014/661/EU, 2014). The laboratory can report results for both free 2-MCPD and 3-MCPD as well as bound as fatty acid esters (2-MCPD ester, 3-MCPD ester) and glycidyl fatty acid ester (GE). The LOQ is 5 µg/kg for free 2-MCPD and 3-MCPD and 10 µg/kg for MCPD fatty acid esters and glycidyl esters in fats and other food items. The laboratory has used two of their validated GC/MS methods, SPO M3121 and a modified version of ISO 18363-2 that corresponds to the SGS "3-in-1" low LOQ. These analysis methods are based on one of the official methods from AOCS (AOCS 29b-13 (AOCS)) and are described in more detail in elsewhere (Kuhlmann, 2011, Kuhlmann, 2016).

A 4.13 Polycyclic aromatic hydrocarbons (PAHs)

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 Benso(a)pyrene according to Commission Regulation (EC) No 333/2007.

The method is accredited against ISO 17025 by SWEDAC for 25 PAHs, but for this report the individual concentration of the four PAHs included in the Sum PAH4 (benz[a]anthracene (BaA), chrysene (CHR), benzo[b]fluoranthene (BbF) and benzo[a]pyrene (BaP)) and the calculated Sum PAH4 were presented. 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.

A 4.14 Mycotoxins

Mycotoxins were analysed at Swedish Food Agency (SFA), Uppsala, Sweden, in December 2023-January 2024 in the two food groups cereals and fruit. The method used for all mycotoxins except patulin is a validated and accredited triple-quadrupole-LC-MS/MS-method where the mycotoxins aflatoxin B1, B2, G1 and G2, ochratoxin A, deoxynivalenol, 3-acetyl-deoxynivalenol, 15-acetyl-deoxynivalenol, zearalenone, T-2- and HT-2-toxin, fumonisin B1 and B2, alternariol and alternariolmethylether and ergot alkaloids were analysed in the same analysis. A portion of 25 g of the homogenised sample were used in the analysis. The sample extraction is performed by shaking with solvent followed by filtration. 13C-isotope-marked internal standards were used in the MS-analysis for all mycotoxins analysed except acetyl-deoxynivalenols, alternaria toxins and ergotalkaloids. 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 was analysed at SFA, Uppsala, Sweden, in December 2023 in the food group fruit. The method used for patulin is a validated, accredited, triple-quadrupole-LC-MS/MS-method. Patulin is extracted by shaking with solvent followed by filtration and centrifugation. The sample is cleaned-up on a solid-phase-column specific for patulin before LC-MS/MS analysis. 13C-isotope-marked internal standard were used in the MS-analysis. The LOQ of the method for patulin is 3 µg/kg.

A 4.15 Fluoride

The analysis of fluoride was performed at the Department of Thematic Studies – Environmental change, Linköping University (LiU), Sweden. Fluoride concentrations of samples were determined in water extracts by GC-MS/MS (gas-chromatography tandem mass spectrometry) (Agilent 8890 GC System with Agilent 7010B TQ) following acidic silanol-derivatization.

Briefly, 5 g of sample was weighed in to 50 ml centrifuge tubes (polypropylene) and ultrasonicated with 5 ml ultrapure water. Solid-liquid separation was achieved by high-speed centrifugation (Avanti J-E, Beckman Coultier) for 15 min and the aqueous supernatant transferred to a new centrifuge tube. The procedure was repeated five times yielding a total extractant volume of 25 ml.

An aliquot of the final extract was then subjected to acidic derivatization converting fluoride to fluorosilane with subsequent GC-MS/MS determination. The GC was equipped with a HP-5ms Ultra Inert column (30 m x 250 µm x 0.25 µm, Agilent J&W Columns) and operated with a helium (He) carrier gas flow of 1 ml/min. Electron ionization (EI) with multiple reaction monitoring (MRM) was used for detection and quantification of the obtained fluorosilane derivative. Limit of detection (LOD) was determined by analysis of 10 ultrapure water blanks and calculated as the average signal of the blanks plus three times the standard deviation of the blank signal. Limit of quantification (LOQ) was determined by the same calculation but with ten times the standard deviation of the blank signal. A certified reference material, procedural blanks and a fortified sample matrix were also prepared along with samples.

A 4.16 References

References in the appendix are found in section 11. References.

Appendix 5. Additional compounds analysed in the Market Basket 2022

A 5.1 Fatty acids

Table A5.1.1 presents concentrations of fatty acids in food groups using lower and upper bound approach. Table A5.1.2 shows the proportion of individual fatty acids of total fatty acids (%) in the food groups.

Table A5.1.1. Concentrations of fatty acids per kg in food groups using lower and upper bound approach in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
FA factor[1]		0.73	0.96	0.95	0.95	0.70	0.90	0.80	0.94	0.94	0.94	0.83	0.96	0.93	0.96	0.96
Fat, total (g/kg)	Mean	36	158	117	197	23	143	104	19	252	25	99	673	27	19	104
	Min	31	147	115	192	20	132	90	18	246	17	99	662	25	17	98
	Median	37	160	117	200	22	133	107	19	249	27	99	669	26	20	104
	Max	40	167	118	200	26	164	116	20	261	32	99	687	30	20	110
SFA (g/kg)	Mean	3.4-3.9	59-61	47-48	75-78	2.0-2.3	22-24	21-22	13-13	166-168	2.4-2.9	25-27	193-200	3.6-4.1	3.4-3.7	53-54
	Min	3.1-3.5	54-56	46-48	74-77	1.8-2.1	20-22	14-15	12-12	160-162	1.6-1.9	25-26	188-195	2.9-3.3	1.5-1.8	50-52
	Median	3.2-3.8	60-62	47-48	75-78	2.0-2.3	20-22	23-24	13-13	164-166	2.8-3.4	25-27	190-197	3.8-4.3	2.0-2.4	52-54
	Max	3.9-4.4	62-64	47-48	76-80	2.2-2.5	25-27	27-28	13-14	173-175	2.9-3.5	26-28	200-207	4.2-4.7	6.5-6.9	55-57
MUFA (g/kg)	Mean	12-13	69-70	53-54	93-94	8.3-8.4	67-68	37-37	4.5-4.5	62-63	13-14	40-40	316-320	16-16	10-11	39-40
	Min	10-10	66-67	53-54	90-91	7.6-7.6	59-59	29-29	4.2-4.3	61-62	8.6-8.7	38-38	314-317	14-14	8.1-8.2	36-37

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Median	12-13	67-68	54-54	93-95	8.0-8.1	64-65	40-41	4.4-4.4	62-62	14-14	41-41	315-319	15-15	11-11	39-39
	Max	15-15	75-76	54-55	94-96	9.5-9.6	79-79	42-43	4.8-4.9	63-63	17-18	41-41	319-323	18-18	12-12	42-42
PUFA (g/kg)	Mean	10-11	24-26	9.9-12	19-21	5.4-5.6	40-40	25-27	0.58-0.90	7.7-12	7.8-8.2	17-18	133-144	5.6-6.0	4.3-4.7	7.8-9.6
	Min	9.0-9.4	21-24	9.2-11	17-20	4.7-4.8	36-36	22-24	0.53-0.84	7.3-11	5.3-5.6	16-17	128-139	5.5-6.0	2.5-2.8	6.9-8.6
	Median	11-11	24-27	10-12	19-22	5.4-5.5	39-40	24-25	0.60-0.92	7.7-12	8.5-8.9	17-18	131-142	5.6-6.1	4.4-4.8	8.0-9.9
	Max	11-12	25-28	11-12	20-22	6.1-6.3	44-45	30-31	0.61-0.95	7.9-12	9.5-10	18-19	139-151	5.7-6.1	6.1-6.4	8.5-10
n-3 PUFA (g/kg)	Mean	1.4-1.7	4.3-5.7	0.87-1.9	1.4-2.9	2.9-3.0	23-23	4.5-5.2	0.10-0.27	1.0-3.1	1.6-1.8	1.9-2.6	36-42	0.58-0.80	0.21-0.38	0.29-1.2
	Min	1.1-1.3	3.7-5.0	0.77-1.8	1.1-2.8	2.6-2.7	20-21	2.8-3.4	0.09-0.24	0.98-3.1	1.1-1.3	1.7-2.4	34-39	0.55-0.75	0.19-0.36	0.25-1.1
	Median	1.5-1.8	4.4-5.9	0.91-1.9	1.4-2.9	3.1-3.1	22-22	5.2-6.0	0.11-0.28	1.0-3.1	1.7-1.9	1.9-2.6	35-41	0.59-0.83	0.19-0.36	0.28-1.2
	Max	1.7-1.9	4.8-6.2	0.93-1.9	1.6-3.1	3.1-3.2	26-26	5.5-6.3	0.11-0.28	1.1-3.3	2.0-2.3	2.1-2.7	39-44	0.61-0.84	0.27-0.41	0.33-1.2
n-6 PUFA (g/kg)	Mean	9.0-9.2	18-19	8.2-8.7	16-17	2.4-2.5	16-16	21-21	0.28-0.40	4.2-5.6	6.2-6.3	15-15	88-92	5.0-5.2	4.1-4.2	6.7-7.4
	Min	8.0-8.1	17-18	7.5-8.1	15-16	2.1-2.1	14-15	17-18	0.25-0.37	4.1-5.5	4.2-4.3	14-14	85-90	4.9-5.1	2.2-2.3	6.0-6.7
	Median	9.2-9.4	19-20	8.2-8.7	17-18	2.3-2.4	16-17	18-19	0.28-0.41	4.2-5.7	6.8-7.0	14-15	87-91	5.1-5.2	4.2-4.4	6.7-7.5
	Max	9.8-	19-	8.8-	17-	3.0-	17-	27-	0.29-	4.3-	7.4-	16-	91-	5.1-	5.9-	7.3-

		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
		10	21	9.4	18	3.0	18	28	0.42	5.7	7.7	16	96	5.3	6.0	8.0
TFA (g/kg)	Mean	0.00-0.16	0.43-1.1	1.6-1.9	0.79-1.7	0.05-0.13	0.88-1.4	0.23-0.56	0.73-0.74	10-11	0.00-0.14	0.11-0.52	6.7-9.3	0.00-0.15	0.03-0.12	0.51-0.91
	Min	0.00-0.13	0.33-1.0	1.5-1.9	0.71-1.7	0.04-0.11	0.75-1.2	0.20-0.51	0.68-0.69	10-10	0.00-0.09	0.10-0.51	5.8-8.5	0.00-0.14	0.00-0.10	0.45-0.82
	Median	0.00-0.16	0.39-1.2	1.5-1.9	0.77-1.7	0.05-0.13	0.85-1.3	0.22-0.55	0.72-0.74	10-11	0.00-0.15	0.11-0.52	6.5-9.1	0.00-0.15	0.04-0.14	0.50-0.90
	Max	0.00-0.18	0.57-1.2	1.7-2.0	0.91-1.8	0.06-0.14	1.0-1.6	0.26-0.63	0.78-0.80	10-11	0.00-0.18	0.12-0.53	7.7-10.3	0.00-0.17	0.05-0.14	0.57-0.99

1 g/kg = 0.1 g/100 g. Lower bound approach, non-detects are set to 0; upper bound approach, non-detects are set to LOQ; NA, not analysed. FA factor, fatty acid factor; SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acids; TFA, trans fatty acid.

[1] FA was not analysed in vegetables due to low total fat content (<0.5% fat). Fat content in beverages and coffee/tea were assumed to be logical zero and no analyses were performed. FAs were not analysed in subgroups pizza/hand pies.

[2] A FA factor was applied to convert the total fat content into grams fatty acids (Greenfield and Southgate, 2003). The factors in Greenfield et al was used with the following exceptions: For cereal products and fruits, mean FA factors were calculated based on total fat and fatty acid contents of the individual foot items in the food group, respectively. Fat content data from Swedish Food Agency´s food composition database were used in the calculations. For pastries, potatoes and sugar/sweets, FA factor for fats and oils (0.96) were used because most fat in these food groups were from fats and oils. For meat and processed meat, FA factor for bovine and poultry (0.95) was used because it was closest to estimated mean FA factor (0.94). For meat substitutes, FA factor for vegetables were used. For plant-based drinks, FA factor for oat was used because most of the sample was oat milk (64%).

Table A5.1.2. Proportion of individual fatty acids of total fatty acids (%) in food groups in the Market Basket 2022 (N=3 samples per food group).

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
4:0	Mean	0	0.32	0	0	0	0	0	3.8	3.7	0	0	0.98	0	0	0.71
	Min	<0.1	0.29	<0.1	<0.1	<0.1	<0.1	<0.1	3.6	3.6	<0.1	<0.1	0.89	<0.1	<0.1	0.70
	Median	<0.1	0.35	<0.1	<0.1	<0.1	<0.1	<0.1	3.9	3.7	<0.1	<0.1	0.99	<0.1	<0.1	0.71
	Max	<0.1	0.32	<0.1	<0.1	<0.1	<0.1	<0.1	3.9	3.7	<0.1	<0.1	1.1	<0.1	<0.1	0.74
6:0	Mean	0	0.16	0	0	0	0	0	1.9	1.8	0	0	0.49	0	0	0.36
	Min	<0.1	0.15	<0.1	<0.1	<0.1	<0.1	<0.1	1.8	1.8	<0.1	<0.1	0.45	<0.1	<0.1	0.35
	Median	<0.1	0.16	<0.1	<0.1	<0.1	<0.1	<0.1	1.9	1.8	<0.1	<0.1	0.50	<0.1	<0.1	0.35
	Max	<0.1	0.17	<0.1	<0.1	<0.1	<0.1	<0.1	2.0	1.9	<0.1	<0.1	0.53	<0.1	<0.1	0.37
8:0	Mean	0	1.0	0	0	0	0	1.2	1.4	1.4	0	0	0.50	0	0	0.70
	Min	<0.1	0.65	<0.1	<0.1	<0.1	<0.1	0.72	1.4	1.4	<0.1	<0.1	0.48	<0.1	<0.1	0.62
	Median	<0.1	1.2	<0.1	<0.1	<0.1	<0.1	1.4	1.4	1.4	<0.1	<0.1	0.50	<0.1	<0.1	0.66
	Max	<0.1	1.2	<0.1	<0.1	<0.1	<0.1	1.6	1.4	1.4	<0.1	<0.1	0.54	<0.1	<0.1	0.82
10:0	Mean	0	0.93	0.12	0	0	0	1.0	3.4	3.4	0	0	0.94	0	0	0.91
	Min	<0.1	0.63	0.13	<0.1	<0.1	<0.1	0.58	3.3	3.4	<0.1	<0.1	0.98	<0.1	<0.1	0.90
	Median	<0.1	1.1	0.11	<0.1	<0.1	<0.1	1.2	3.4	3.3	<0.1	<0.1	0.91	<0.1	<0.1	0.85
	Max	<0.1	1.1	0.11	<0.1	<0.1	<0.1	1.3	3.4	3.5	<0.1	<0.1	0.94	<0.1	<0.1	0.99
10:1	Mean	0	0	0	0	0.10	0	0	0.28	0.25	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.27	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.28	0.25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	0.21	<0.1	<0.1	0.28	0.26	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
11:0	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
12:0	Mean	0.23	7.3	0.16	0.07	0	0	8.1	3.8	3.8	0	0	2.3	0	0.07	3.4

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Min	<0.1	4.6	0.16	<0.1	<0.1	<0.1	4.5	3.7	3.7	<0.1	<0.1	2.2	<0.1	<0.1	3.0
	Median	0.28	8.6	0.16	<0.1	<0.1	<0.1	9.4	3.8	3.9	<0.1	<0.1	2.2	<0.1	<0.1	3.2
	Max	0.37	8.7	0.17	0.11	<0.1	<0.1	10	4.0	3.9	<0.1	<0.1	2.4	<0.1	0.12	4.0
12:1	Mean	0	0	0	0	0	0	0	0.20	0.19	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.19	0.18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.20	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.21	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
13:0	Mean	0	0	0	0	0	0	0	0.09	0.11	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
14:0	Mean	0.18	3.4	2.0	1.4	0.51	3.2	3.2	12	11	0	0.26	3.6	0.07	0.26	3.3
	Min	0.11	2.5	1.9	1.4	0.45	3.1	1.8	12	11	<0.1	0.24	3.5	<0.1	<0.1	3.2
	Median	0.20	3.8	2.0	1.4	0.51	3.2	3.7	12	11	<0.1	0.27	3.6	<0.1	<0.1	3.4
	Max	0.24	4.0	2.1	1.5	0.55	3.4	4.2	12	11	<0.1	0.28	3.6	0.11	0.68	3.4
14:0 iso	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
14:1	Mean	0	0	0.24	0	0	0	0	1.1	1.0	0	0	0.26	0	0	0.19
	Min	<0.1	<0.1	0.19	<0.1	<0.1	<0.1	<0.1	1.1	1.0	<0.1	<0.1	0.26	<0.1	<0.1	0.17
	Median	<0.1	<0.1	0.24	<0.1	<0.1	<0.1	<0.1	1.1	1.0	<0.1	<0.1	0.26	<0.1	<0.1	0.17
	Max	<0.1	<0.1	0.29	<0.1	<0.1	<0.1	<0.1	1.1	1.0	<0.1	<0.1	0.27	<0.1	<0.1	0.22
14:1 trans	Mean	0	0	0	0	0	0	0	0.22	0.20	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.22	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.22	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.22	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
15:0	Mean	0	0	0.22	0	0.11	0.23	0	1.1	1.1	0	0	0.29	0	0	0.21
	Min	<0.1	<0.1	0.21	<0.1	0.11	0.22	<0.1	1.0	1.1	<0.1	<0.1	0.29	<0.1	<0.1	0.20
	Median	<0.1	<0.1	0.21	<0.1	0.11	0.23	<0.1	1.1	1.1	<0.1	<0.1	0.29	<0.1	<0.1	0.20
	Max	<0.1	<0.1	0.23	<0.1	0.12	0.24	<0.1	1.1	1.1	<0.1	<0.1	0.29	<0.1	<0.1	0.23
15:0 anteiso	Mean	0	0	0	0	0	0	0	0.39	0.40	0	0	0.11	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.39	0.39	<0.1	<0.1	0.11	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.39	0.40	<0.1	<0.1	0.11	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.39	0.41	<0.1	<0.1	0.12	<0.1	<0.1	<0.1
15:0 iso	Mean	0	0	0	0	0	0.11	0	0.23	0.23	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	0.23	0.23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	0.23	0.23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	0.24	0.23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15:1	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16:0	Mean	10	18	25	25	9	11	6.8	32	31	7.1	23	14	11	13	26
	Min	9.3	15	25	24	8.6	10	6.5	32	31	6.7	22	14	9.8	5.3	25
	Median	9.5	17	25	24	9.4	10	6.7	32	31	7.0	23	15	11	6.0	26
	Max	11	21	25	25	9.5	11	7.2	32	32	7.5	24	15	12	29	27
16:0 anteiso	Mean	0	0	0.17	0	0.07	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	0.17	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.18	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16:0 iso	Mean	0	0	0	0	0	0	0	0.20	0.19	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.19	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.20	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.20	0.20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16:1	Mean	0.23	0.38	3.1	2.8	1.1	3.0	0.17	1.6	1.7	0.21	2.9	0.61	2.3	0.18	0.46
	Min	0.22	0.34	3.0	2.7	0.97	3.0	0.14	1.6	1.7	0.21	2.7	0.60	1.2	0.15	0.42
	Median	0.22	0.37	3.2	2.9	1.1	3.0	0.18	1.6	1.7	0.21	3.0	0.61	2.3	0.19	0.46
	Max	0.24	0.42	3.2	2.9	1.3	3.1	0.18	1.7	1.7	0.21	3.1	0.63	3.6	0.19	0.52
16:1 trans	Mean	0	0	0.11	0	0	0	0	0.30	0.31	0	0	0	0	0	0
	Min	<0.1	<0.1	0.10	<0.1	<0.1	<0.1	<0.1	0.30	0.30	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.10	<0.1	<0.1	<0.1	<0.1	0.30	0.32	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	0.31	0.33	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16:2 n-4	Mean	0	0	0	0	0.09	0.36	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.36	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	0.11	0.36	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	0.12	0.37	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16:3	Mean	0	0	0.45	0.39	0.13	0.12	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	0.45	0.37	0.12	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.45	0.39	0.14	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.46	0.41	0.14	0.13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
16:4 n-3	Mean	0	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
17:0	Mean	0	0.09	0.54	0.39	0.13	0.16	0	0.45	0.46	0	0.18	0.14	0	0	0.19
	Min	<0.1	<0.1	0.52	0.36	0.13	0.15	<0.1	0.44	0.46	<0.1	0.17	0.14	<0.1	<0.1	0.17
	Median	<0.1	0.11	0.55	0.38	0.13	0.16	<0.1	0.45	0.46	<0.1	0.18	0.14	<0.1	<0.1	0.19
	Max	<0.1	0.11	0.57	0.43	0.14	0.16	<0.1	0.46	0.47	<0.1	0.18	0.14	<0.1	<0.1	0.21
17:0 anteiso	Mean	0	0	0.24	0.07	0	0	0	0.32	0.36	0	0	0	0	0	0
	Min	<0.1	<0.1	0.23	<0.1	<0.1	<0.1	<0.1	0.32	0.35	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Median	<0.1	<0.1	0.24	<0.1	<0.1	<0.1	<0.1	0.32	0.36	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.26	0.10	<0.1	<0.1	<0.1	0.34	0.37	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
17:0 iso	Mean	0	0	0.16	0	0	0	0	0.40	0.41	0	0	0.09	0	0	0
	Min	<0.1	<0.1	0.15	<0.1	<0.1	<0.1	<0.1	0.38	0.41	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.16	<0.1	<0.1	<0.1	<0.1	0.40	0.42	<0.1	<0.1	0.11	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.18	<0.1	<0.1	<0.1	<0.1	0.41	0.42	<0.1	<0.1	0.11	<0.1	<0.1	<0.1
17:1	Mean	0	0	0	0	0	0.16	0	0.16	0.18	0	0.10	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.16	<0.1	0.16	0.18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	0.16	<0.1	0.16	0.19	<0.1	0.12	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	0.17	<0.1	0.17	0.19	<0.1	0.12	<0.1	<0.1	<0.1	<0.1
18:0	Mean	2.1	7.1	14	13	2.2	2.2	3.6	9.8	9.9	2.6	7.4	5.5	2.1	3.3	16
	Min	1.9	7.0	13	13	2.2	2.0	3.0	9.5	9.7	2.4	7.2	5.1	1.5	2.7	16
	Median	2.0	7.0	14	14	2.2	2.1	3.9	9.7	9.7	2.6	7.3	5.5	2.1	3.3	16
	Max	2.5	7.2	14	14	2.2	2.4	3.9	10	10	2.8	7.8	5.8	2.5	3.9	16
18:0 anteiso	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
18:0 iso	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
18:1	Mean	46	45	44	46	50	36	43	21	23	55	45	47	60	58	38
	Min	44	43	44	45	49	35	39	21	22	54	43	46	57	42	38
	Median	45	46	44	46	50	37	44	21	23	54	46	48	60	57	38
	Max	49	46	44	46	50	37	46	22	23	57	46	48	63	74	39
18:1 trans	Mean	0	0.24	0.99	0.42	0.31	0.48	0.15	2.7	3.0	0	0.13	0.82	0	0	0.37

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Min	<0.1	0.23	0.95	0.37	0.29	0.44	0.13	2.6	2.9	<0.1	0.12	0.69	<0.1	<0.1	0.35
	Median	<0.1	0.24	0.97	0.40	0.31	0.46	0.15	2.6	3.0	<0.1	0.13	0.81	<0.1	<0.1	0.37
	Max	<0.1	0.25	1.1	0.50	0.34	0.54	0.17	2.7	3.2	<0.1	0.15	0.96	<0.1	<0.1	0.40
18:2	Mean	34	13	7.1	8.2	15	11	26	2.6	2.7	26	16	15	20	22	7.5
	Min	31	12	6.7	7.6	14	10	20	2.6	2.6	25	15	15	18	14	7.1
	Median	36	13	7.1	8.4	14	11	20	2.6	2.6	27	16	15	21	22	7.3
	Max	36	13	7.6	8.6	16	12	38	2.7	2.9	27	17	15	22	31	8.2
18:2 n-6	Mean	34	12	6.8	8.1	15	11	26	1.5	1.7	26	16	14	20	22	6.7
	Min	31	12	6.3	7.5	14	10	20	1.5	1.6	25	15	13	18	14	6.4
	Median	36	12	6.8	8.3	14	11	20	1.5	1.7	27	16	14	21	22	6.4
	Max	36	12	7.3	8.5	16	12	38	1.6	1.7	27	17	14	22	30	7.3
18:2 conj	Mean	0	0	0.19	0.10	0	0	0.11	0.48	0.45	0.12	0	0.23	0	0	0
	Min	<0.1	<0.1	0.18	<0.1	<0.1	<0.1	<0.1	0.48	0.44	0.11	<0.1	0.22	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.19	0.12	<0.1	<0.1	0.13	0.48	0.46	0.11	<0.1	0.23	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.21	0.12	<0.1	<0.1	0.14	0.49	0.46	0.15	<0.1	0.23	<0.1	<0.1	<0.1
18:2 trans	Mean	0	0.07	0.32	0	0	0.20	0.09	0.70	0.72	0	0	0.22	0	0.17	0.13
	Min	<0.1	<0.1	0.32	<0.1	<0.1	0.17	<0.1	0.69	0.71	<0.1	<0.1	0.19	<0.1	<0.1	0.11
	Median	<0.1	<0.1	0.32	<0.1	<0.1	0.18	<0.1	0.69	0.71	<0.1	<0.1	0.22	<0.1	0.21	0.14
	Max	<0.1	0.11	0.34	<0.1	<0.1	0.26	0.16	0.71	0.74	<0.1	<0.1	0.24	<0.1	0.24	0.15
18:3 n-3	Mean	5.4	2.8	0.79	0.65	5.3	4.5	5.3	0.57	0.43	6.9	1.1	5.5	2.3	1.2	0.29
	Min	4.9	2.6	0.71	0.61	4.8	4.4	3.8	0.52	0.43	6.5	1.0	5.3	2.1	0.98	0.27
	Median	5.2	2.8	0.81	0.61	5.0	4.5	5.9	0.56	0.43	6.8	1.1	5.5	2.4	0.98	0.27
	Max	6.2	3.1	0.84	0.72	6.2	4.5	6.1	0.63	0.43	7.3	1.2	5.8	2.5	1.7	0.33
18:3 n-3 trans	Mean	0	0	0	0	0	0	0.09	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
18:3 n-6	Mean	0	0	0	0	0	0.14	0	0	0	0	0.07	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	0.16	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1
18:4 n-3	Mean	0	0	0	0	0.14	1.2	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	0.12	1.16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	0.14	1.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	0.16	1.23	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20:0	Mean	0.32	0.39	0.17	0.19	0.40	0.28	0.39	0.16	0.15	0.43	0.00	0.42	0.35	0.37	0.51
	Min	0.27	0.38	0.16	0.18	0.38	0.28	0.33	0.16	0.15	0.42	<0.1	0.41	0.26	0.34	0.47
	Median	0.33	0.38	0.17	0.18	0.41	0.29	0.41	0.16	0.15	0.43	<0.1	0.42	0.32	0.38	0.50
	Max	0.36	0.41	0.18	0.19	0.43	0.29	0.43	0.16	0.15	0.45	<0.1	0.44	0.47	0.40	0.55
20:1	Mean	0.75	0.45	0.71	0.90	1.5	6.2	0.71	0.14	0.12	0.91	0.26	0.67	0.77	0.45	0.13
	Min	0.62	0.44	0.69	0.88	1.4	5.6	0.46	0.14	0.11	0.87	0.22	0.64	0.65	0.30	0.12
	Median	0.79	0.44	0.71	0.89	1.5	6.4	0.83	0.14	0.11	0.90	0.27	0.67	0.68	0.45	0.12
	Max	0.85	0.47	0.73	0.93	1.7	6.5	0.83	0.15	0.13	0.96	0.30	0.70	0.97	0.59	0.16
20:1 trans	Mean	0	0	0	0	0	0	0	0.13	0.12	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.13	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.13	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.14	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20:2 n-6	Mean	0	0	0.24	0.37	0.11	0.78	0	0	0	0	0.13	0	0	0	0
	Min	<0.1	<0.1	0.22	0.34	0.10	0.71	<0.1	<0.1	<0.1	<0.1	0.13	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.24	0.37	0.11	0.72	<0.1	<0.1	<0.1	<0.1	0.13	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.26	0.40	0.11	0.92	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	<0.1	<0.1	<0.1
20:3 n-3	Mean	0	0	0	0.09	0	0.35	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.30	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	0.11	<0.1	0.33	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Max	<0.1	<0.1	<0.1	0.11	<0.1	0.42	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20:3 n-6	Mean	0	0	0	0	0	0.15	0	0	0	0	0.13	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.13	<0.1	<0.1	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	<0.1	<0.1	<0.1	<0.1	0.13	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	0.17	<0.1	<0.1	<0.1	<0.1	0.13	<0.1	<0.1	<0.1	<0.1
20:4 n-3	Mean	0	0	0	0	0.09	0.73	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.61	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	0.10	0.76	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	0.11	0.82	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20:4 n-6	Mean	0	0	0.33	0.27	0.58	0.26	0	0	0.11	0	1.58	0	0	0	0
	Min	<0.1	<0.1	0.31	0.26	0.55	0.24	<0.1	<0.1	0.11	<0.1	1.6	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	0.33	0.28	0.59	0.24	<0.1	<0.1	0.11	<0.1	1.6	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	0.35	0.28	0.60	0.28	<0.1	<0.1	0.11	<0.1	1.6	<0.1	<0.1	<0.1	<0.1
20:5 n-3	Mean	0	0	0	0	5.0	3.6	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	4.2	3.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	5.3	3.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	5.4	3.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
21:5 n-3	Mean	0	0	0	0	0	0.18	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	0.17	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	0.18	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
22:0	Mean	0.26	0.21	0	0	0.21	0.12	0.30	0	0	0.24	0	0.20	0.68	0.55	0.11
	Min	0.23	0.17	<0.1	<0.1	0.20	0.11	0.24	<0.1	<0.1	0.24	<0.1	0.20	0.50	0.26	<0.1
	Median	0.27	0.20	<0.1	<0.1	0.21	0.12	0.24	<0.1	<0.1	0.24	<0.1	0.20	0.54	0.70	<0.1
	Max	0.28	0.26	<0.1	<0.1	0.24	0.13	0.43	<0.1	<0.1	0.25	<0.1	0.20	1.0	0.70	0.22
22:1	Mean	0.34	0	0	0	0.41	6.5	0.07	0	0	0.11	0	0.07	0.11	0.15	0
	Min	0.28	<0.1	<0.1	<0.1	0.30	5.5	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	0.10	<0.1	<0.1

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Median	0.36	<0.1	<0.1	<0.1	0.39	7.0	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	0.10	0.18	<0.1
	Max	0.37	<0.1	<0.1	<0.1	0.55	7.1	0.11	<0.1	<0.1	0.12	<0.1	0.10	0.14	0.24	<0.1
22:2 n-6	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0.07	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1
22:4 n-3	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
22:4 n-6	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
22:5 n-3	Mean	0	0	0	0	0.24	0.96	0	0	0	0	0.07	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	0.21	0.82	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	0.24	0.95	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	0.27	1.1	<0.1	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	<0.1	<0.1
22:5 n-6	Mean	0	0	0	0	0.15	0.13	0	0	0	0	0.08	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	0.13	0.11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	0.14	0.14	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	0.17	0.15	<0.1	<0.1	<0.1	<0.1	0.14	<0.1	<0.1	<0.1	<0.1
22:6 n-3	Mean	0	0	0	0	7.9	6.2	0	0	0	0	1.2	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	6.8	5.8	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	8.0	6.2	<0.1	<0.1	<0.1	<0.1	1.2	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	9.0	6.5	<0.1	<0.1	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1
23:0	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fatty acid		Cereal products	Pastries	Meat	*Processed meat*	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Fruits	Potatoes	Sugar and sweets
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
24:0	Mean	0	0	0	0	0	0	0.08	0	0	0	0	0	0.48	0.21	0.07
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.37	0.12	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.40	0.13	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.15	<0.1	<0.1	<0.1	<0.1	<0.1	0.68	0.25	0.12
24:1 n-9	Mean	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Min	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Median	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	Max	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

< indicates a value below limit of quantification (LOQ=0.1%).

Individual fatty acids were not analysed the food groups subgroup pizza/hand pies, vegetables, beverages and coffee/tea.

A 5.2 Vitamins

Table A5.2.1. Concentrations of carotenoids, tocopherols, tocotrienols, and menaquinones in food groups in the Market Basket 2022 (N=3 samples per food group).

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
Lutein[1] (µg/kg)	Mean	820	605	0*	0*	0*	737	0	0	126	1927	135	2407	615	207	52	0*
	Min	750	590				691	<50	<50	105	1770	80	2320	510	175	<50	
	Median	846	594				701	<50	<50	133	1880	87	2440	640	177	53	
	Max	864	631				818	<50	<50	141	2130	239	2460	696	269	78	
Lycopene[1] (µg/kg)	Mean	0	3573	0*	0*	0*	169	0	0	0	0	833	18500	0	0	0	0*
	Min	<50	1540				124	<50	<50	<50	<50	525	15900	<50	<50	<50	
	Median	<50	4530				165	<50	<50	<50	<50	835	18800	<50	<50	<50	
	Max	<50	4650				218	<50	<50	<50	<50	1140	20800	<50	<50	<50	
Xeaxanthine[1] (µg/kg)	Mean	102	52	0*	0*	0*	228	0	0	0	1008	0	259	164	0	0	0*
	Min	92	<50				149	<50	<50	<50	839	<50	165	131	<50	<50	
	Median	101	56				262	<50	<50	<50	1044	<50	303	175	<50	<50	
	Max	114	75				272	<50	<50	<50	1140	<50	310	187	<50	<50	
β-tocopherol (mg/kg)	Mean	1.7	1.9	0	0	0	0.57	0	0	0	1.2	0	0	0	0	0.27	0
	Min	1.7	1.6	<0.4	<0.4	<0.4	0.52	<0.4	<0.4	<0.4	0.86	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Median	1.7	1.9	<0.4	<0.4	<0.4	0.57	<0.4	<0.4	<0.4	1.1	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
	Max	1.9	2.2	<0.4	<0.4	<0.4	0.63	<0.4	<0.4	<0.4	1.5	<0.4	<0.4	<0.4	<0.4	0.42	<0.4
δ-tocopherol (mg/kg)	Mean	0	0.85	0	0	0.34	3.9	0	0	1.7	0.31	1.8	0	0.48	0	0.83	0
	Min	<0.4	0.57	<0.4	<0.4	<0.4	2.0	<0.4	<0.4	1.3	<0.4	1.4	<0.4	0.43	<0.4	0.67	<0.4
	Median	<0.4	0.72	<0.4	<0.4	<0.4	4.3	<0.4	<0.4	1.5	<0.4	1.5	<0.4	0.45	<0.4	0.79	<0.4
	Max	<0.4	1.3	<0.4	<0.4	0.61	5.4	<0.4	<0.4	2.3	0.53	2.4	<0.4	0.56	<0.4	1.0	<0.4
γ-tocopherol (mg/kg)	Mean	4.5	20	0.68	3.7	19	27	0	0	11	6.8	126	2.0	3.0	0.30	8.6	0
	Min	3.3	16	0.62	2.9	19	9.5	<0.4	<0.4	9.6	5.5	121	1.5	2.4	<0.4	6.8	<0.4
	Median	4.6	20	0.63	3.6	19	35	<0.4	<0.4	12	7.4	128	2.3	3.4	<0.4	9.1	<0.4

		Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
	Max	5.5	23	0.78	4.6	19	37	<0.4	<0.4	13	7.4	129	2.3	3.4	0.51	9.8	<0.4
α-tocotrienol (mg/kg)	Mean	2.3	5.9	0.43	0	0	0	0	0	0.65	1.0	3.6	0	0	0	3.6	0
	Min	1.6	4.8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.52	0.73	2.9	<0.4	<0.4	<0.4	3.0	<0.4
	Median	2.4	6.0	0.46	<0.4	<0.4	<0.4	<0.4	<0.4	0.69	0.92	4.0	<0.4	<0.4	<0.4	3.2	<0.4
	Max	2.7	6.8	0.64	<0.4	<0.4	<0.4	<0.4	<0.4	0.75	1.3	4.1	<0.4	<0.4	<0.4	4.4	<0.4
β-tocotrienol (mg/kg)	Mean	11.3	8.9	0	0.27	0	0.75	0	0	0	0.79	0.72	0	0	0	1.1	0
	Min	11	8.3	<0.4	<0.4	<0.4	0.70	<0.4	<0.4	<0.4	0.67	0.55	<0.4	<0.4	<0.4	0.92	<0.4
	Median	11	9.1	<0.4	<0.4	<0.4	0.76	<0.4	<0.4	<0.4	0.77	0.72	<0.4	<0.4	<0.4	1.1	<0.4
	Max	12	9.4	<0.4	0.40	<0.4	0.78	<0.4	<0.4	<0.4	0.94	0.90	<0.4	<0.4	<0.4	1.2	<0.4
δ-tocotrienol (mg/kg)	Mean	0	1.4	0	0	0	0	0.45	0	0	0	0.35	0	0.39	0	2.2	0
	Min	<0.4	1.0	<0.4	<0.4	<0.4	<0.4	0.42	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.9	<0.4
	Median	<0.4	1.3	<0.4	<0.4	<0.4	<0.4	0.45	<0.4	<0.4	<0.4	0.43	<0.4	0.45	<0.4	2.3	<0.4
	Max	<0.4	1.8	<0.4	<0.4	<0.4	<0.4	0.49	<0.4	<0.4	<0.4	0.43	<0.4	0.52	<0.4	2.5	<0.4
γ-tocotrienol (mg/kg)	Mean	0.61	8.4	0.98	0	0	1.1	0	0	0	0	5.2	0.30	0.39	0	7.7	0
	Min	0.54	6.1	0.53	<0.4	<0.4	0.84	<0.4	<0.4	<0.4	<0.4	3.9	<0.4	<0.4	<0.4	6.2	<0.4
	Median	0.64	8.5	0.89	<0.4	<0.4	1.2	<0.4	<0.4	<0.4	<0.4	5.6	<0.4	<0.4	<0.4	7.1	<0.4
	Max	0.65	11	1.5	<0.4	<0.4	1.3	<0.4	<0.4	<0.4	<0.4	5.9	0.51	0.76	<0.4	10	<0.4
Menaquinone-7 (µg/kg)	Mean	NA	NA	NA	NA	NA	NA	NA	6.8	NA	NA	NA	NA	NA	NA	NA	NA
	Min								<10								
	Median								<10								
	Max								10								
Menaquinone-8 (µg/kg)	Mean	NA	NA	NA	NA	NA	NA	NA	55	NA	NA	NA	NA	NA	NA	NA	NA
	Min								50								
	Median								57								
	Max								57								
Menaquinone-9 (µg/kg)	Mean	NA	NA	NA	NA	NA	NA	<10	168	NA	<10	NA	NA	NA	NA	NA	NA
	Min							<10	155		<10						
	Median							<10	172		<10						

	Cereal products	Pastries	Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils	Vegetables	Fruits	Potatoes	Sugar and sweets	Beverages
Max							<10	176		<10						

1 g/kg = 0.1 g/100 g. NA, not analysed.

0*, content was assumed to be logical zero and no analyses were performed.

< indicates a value below limit of quantification (LOQ). When calculating means as well as concentrations of vitamin A, D and K, medium bound concentration (0.5*LOQ) was imputed for non-detects, with exception for when all three samples in one food group had concentrations of an element below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

No analyses were performed in the food groups subgroup pizza/hand pies, and coffee/tea.

[1] The analyses of lutein, lycopene and xeaxanthine are not included in the accreditation.

A 5.3 PCBs and dioxins

Table A5.3.1. Concentrations of PCBs, PCDDs and PCDFs in food groups (fresh weight basis) in food groups in the Market Basket 2022 (N=3 samples per food group).

Compound		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
CB 28	Min	<0.004	<0.01	0.091	<0.01	<0.0003	<0.01	<0.0002	<0.01	<0.04
(ng/g)	Median	<0.004	<0.01	0.110	<0.01	<0.0003	<0.02	<0.0004	<0.01	<0.05
	Max	<0.01	<0.01	0.110	<0.01	<0.0003	<0.02	<0.0004	<0.01	<0.05
CB 52	Min	<0.004	<0.01	0.240	<0.01	<0.0003	<0.01	<0.0004	<0.004	<0.02
(ng/g)	Median	<0.004	<0.01	0.260	<0.01	<0.0004	<0.01	<0.0004	<0.004	<0.02
	Max	<0.004	0.016	0.310	<0.01	<0.0004	<0.01	<0.001	<0.005	<0.03
CB 101	Min	<0.004	<0.02	0.360	<0.004	<0.0002	<0.01	<0.0003	<0.005	<0.01
(ng/g)	Median	<0.01	0.020	0.420	<0.004	<0.0003	<0.01	<0.0003	<0.006	<0.01
	Max	<0.01	0.024	0.550	<0.004	<0.0004	<0.01	<0.001	0.007	0.016
CB 138	Min	0.018	0.015	0.360	<0.003	0.002	0.036	<0.00001	0.024	0.025
(ng/g)	Median	0.021	0.026	0.500	<0.004	0.002	0.044	<0.00002	0.025	0.031
	Max	0.021	0.029	0.640	<0.01	0.003	0.046	<0.0001	0.034	0.035
CB 153	Min	0.026	0.027	0.660	<0.003	0.003	0.043	<0.0002	0.037	0.027
(ng/g)	Median	0.032	0.044	0.860	<0.005	0.003	0.054	<0.0003	0.042	0.049
	Max	0.033	0.045	1.05	<0.01	0.004	0.061	<0.0004	0.053	0.052
CB 180	Min	0.012	0.007	0.170	0.001	0.001	0.017	<0.00001	0.010	0.011
(ng/g)	Median	0.012	0.009	0.210	0.008	0.001	0.021	<0.0001	0.012	0.024
	Max	0.013	0.011	0.260	0.020	0.001	0.022	<0.0002	0.015	0.047
CB 77	Min	<0.19	<0.36	4.26	<0.25	0.043	<0.56	<0.03	<0.45	<0.91
(pg/g)	Median	<0.21	<0.44	5.43	<0.36	0.057	<0.56	0.033	<0.47	<0.95
	Max	<0.22	<0.45	5.43	<0.38	0.057	<0.66	0.058	<0.67	<1.4
CB 81	Min	<0.003	0.016	0.180	<0.003	0.002	0.044	<0.001	<0.03	<0.06
(pg/g)	Median	<0.01	0.028	0.250	<0.003	0.002	0.052	0.001	<0.03	<0.06
	Max	0.016	0.028	0.260	<0.005	0.002	0.055	0.002	<0.03	<0.07
CB 105	Min	<1.7	4.22	70.9	<1.2	0.250	<5.7	<0.05	5.90	<5.2

Compound		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
(pg/g)	Median	<2.0	6.79	92.5	<1.2	0.260	<5.7	<0.06	5.91	<5.8
	Max	<2.2	8.55	137	<1.3	0.280	<7.2	<0.11	6.01	<5.8
CB 114	Min	0.170	<0.09	4.23	<0.04	<0.02	0.340	<0.03	0.350	<0.52
(pg/g)	Median	0.220	0.300	5.90	<0.13	<0.03	0.420	<0.03	0.370	0.510
	Max	0.240	0.400	8.84	0.082	<0.03	0.460	<0.04	0.430	0.610
CB 118	Min	<7.6	14.2	261	<2.3	1.20	19.9	<0.14	18.3	<19
(pg/g)	Median	9.42	21.9	335	<2.7	1.23	23.5	<0.23	18.6	<19
	Max	10.8	24.4	498	<3.0	1.41	25.8	<0.29	21.1	<23
CB 123	Min	<1.6	<1.05	<7.4	<0.52	<0.15	<1.0	<0.23	<0.85	<3.1
(pg/g)	Median	<2.1	<2.0	<10	<0.63	<0.22	<1.1	<0.24	<0.90	<3.2
	Max	<2.2	<2.3	<10	<0.64	<0.23	<1.4	<0.25	<1.0	<3.7
CB 126	Min	0.100	0.084	1.59	<0.01	0.019	0.330	<0.006	0.120	0.190
(pg/g)	Median	0.120	0.150	1.91	<0.02	0.022	0.350	<0.007	0.120	0.260
	Max	0.130	0.160	2.53	<0.02	0.023	0.360	<0.01	0.250	0.340
CB 156	Min	1.62	1.01	22.1	<0.23	0.200	2.53	<0.004	1.53	1.84
(pg/g)	Median	1.78	1.87	28.3	<0.30	0.210	3.41	<0.005	1.77	2.74
	Max	1.80	2.22	44.4	<0.46	0.240	3.59	<0.03	2.59	3.45
CB 157	Min	0.280	0.250	7.34	<0.04	0.028	0.420	<0.002	0.350	<0.12
(pg/g)	Median	0.340	0.600	9.51	<0.04	0.040	0.570	<0.003	0.440	0.220
	Max	0.380	0.610	12.9	<0.07	0.046	0.580	<0.005	0.490	0.540
CB 167	Min	0.760	0.690	17.1	<0.13	0.110	1.68	<0.004	0.950	0.890
(pg/g)	Median	0.830	1.31	23.8	<0.29	0.120	1.96	<0.005	1.04	1.64
	Max	0.960	1.45	28.2	<0.51	0.120	2.07	0.012	1.60	1.97
CB 169	Min	0.020	<0.003	0.420	<0.002	0.002	0.049	<0.0003	0.033	0.026
(pg/g)	Median	0.026	0.030	0.490	<0.002	0.003	0.053	<0.0003	0.037	0.034
	Max	0.027	0.047	0.610	<0.003	0.004	0.055	<0.0004	0.047	0.043
CB 189	Min	0.170	0.110	2.81	<0.003	<0.02	0.320	<0.001	0.150	0.097
(pg/g)	Median	0.170	0.170	3.39	<0.02	<0.02	0.410	<0.003	0.180	0.310
	Max	0.210	0.220	4.27	0.076	<0.03	0.470	<0.004	0.280	0.410

Compound		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
1,2,3,4,6,7,8-HpCDD	Min	<0.02	<0.01	<0.04	<0.01	<0.001	0.097	<0.001	<0.02	<0.08
(pg/g)	Median	<0.02	<0.01	<0.05	<0.01	<0.001	0.110	<0.001	<0.02	<0.08
	Max	0.015	<0.02	0.041	0.033	0.001	0.140	<0.002	<0.02	<0.10
1,2,3,4,7,8-HxCDD	Min	<0.002	<0.002	<0.01	<0.002	<0.001	<0.005	<0.0004	<0.002	0.010
(pg/g)	Median	<0.002	<0.002	<0.01	<0.003	<0.0003	0.014	<0.0004	<0.002	0.011
	Max	<0.002	<0.004	<0.01	<0.004	<0.0003	0.028	<0.001	0.003	0.027
1,2,3,6,7,8-HxCDD	Min	<0.002	<0.002	<0.01	<0.002	<0.0003	<0.005	<0.0004	0.004	0.023
(pg/g)	Median	0.004	<0.002	<0.01	<0.002	0.001	0.020	<0.0004	0.007	0.026
	Max	0.005	<0.003	<0.01	<0.004	0.001	0.032	<0.001	0.010	0.028
1,2,3,7,8,9-HxCDD	Min	<0.002	<0.002	<0.01	<0.003	<0.0004	<0.01	<0.0005	0.003	<0.01
(pg/g)	Median	<0.002	<0.002	<0.01	<0.003	0.0004	<0.01	<0.001	0.004	0.022
	Max	<0.002	<0.004	<0.01	<0.004	0.001	0.014	<0.001	0.006	0.029
1,2,3,7,8-PeCDD	Min	<0.004	<0.004	<0.02	<0.005	<0.001	<0.01	<0.001	<0.004	<0.02
(pg/g)	Median	<0.005	<0.004	<0.03	<0.008	<0.001	<0.02	<0.001	<0.007	<0.02
	Max	<0.01	<0.01	<0.03	<0.01	<0.001	0.051	<0.001	0.005	0.054
2,3,7,8-TCDD	Min	<0.002	<0.002	<0.01	<0.002	<0.0002	<0.01	<0.0003	0.004	<0.01
(pg/g)	Median	<0.003	<0.002	<0.01	<0.002	<0.0003	<0.01	<0.0004	0.004	<0.01
	Max	<0.003	<0.003	<0.01	<0.003	<0.0003	0.007	<0.001	0.004	<0.02
OCDD	Min	<0.05	<0.03	<0.10	<0.13	<0.002	<0.32	<0.001	<0.07	<0.61
(pg/g)	Median	<0.06	<0.03	<0.12	<0.14	<0.002	<0.49	0.013	<0.07	<0.83
	Max	<0.06	<0.09	<0.13	<0.26	0.006	<0.50	0.035	<0.08	<0.86
1,2,3,4,6,7,8-HpCDF	Min	<0.02	<0.01	<0.10	<0.02	<0.0001	<0.07	<0.0001	0.009	0.032
(pg/g)	Median	<0.02	<0.01	<0.13	<0.02	<0.0001	<0.18	<0.0002	0.009	0.210
	Max	<0.03	<0.01	<0.14	<0.03	0.0004	0.220	0.001	0.060	0.230
1,2,3,4,7,8,9-HpCDF	Min	<0.001	<0.001	<0.01	<0.002	<0.0001	0.012	<0.0002	0.003	0.041
(pg/g)	Median	<0.002	<0.003	<0.03	<0.003	<0.0001	0.038	<0.0002	0.009	0.041
	Max	<0.002	<0.004	<0.03	<0.006	<0.0002	0.045	<0.0002	0.015	0.052
1,2,3,4,7,8-HxCDF	Min	<0.01	<0.005	0.056	<0.004	<0.001	<0.04	<0.001	0.005	<0.02
(pg/g)	Median	0.012	0.007	0.061	<0.01	<0.001	0.120	<0.001	0.007	0.150

Compound		Meat	Lean fish	Fatty fish	Meat substitutes	Lean dairy products	Fatty dairy products	Plant-based drinks	Eggs	Fats and oils
	Max	0.020	0.010	0.077	<0.01	<0.001	0.150	<0.001	0.033	0.190
1,2,3,6,7,8-HxCDF (pg/g)	Min	<0.01	<0.005	0.053	<0.004	<0.001	0.030	<0.001	0.003	<0.02
	Median	<0.01	<0.01	0.060	0.007	<0.001	0.065	<0.001	0.007	0.089
	Max	0.011	<0.01	0.063	0.011	<0.001	0.075	<0.001	0.026	0.092
1,2,3,7,8,9-HxCDF (pg/g)	Min	<0.01	<0.01	<0.03	<0.007	<0.001	<0.01	<0.001	<0.004	<0.02
	Median	<0.01	<0.01	<0.03	<0.01	<0.001	0.030	<0.001	0.008	<0.03
	Max	<0.01	<0.01	<0.04	0.007	<0.001	0.042	<0.001	0.010	0.047
1,2,3,7,8-PeCDF (pg/g)	Min	<0.01	<0.005	<0.05	<0.007	<0.001	<0.01	<0.002	0.006	<0.02
	Median	<0.01	<0.01	0.067	<0.01	<0.001	0.080	<0.002	0.008	0.074
	Max	<0.01	<0.01	0.072	0.016	<0.001	0.110	<0.002	0.026	0.100
2,3,4,6,7,8-HxCDF (pg/g)	Min	<0.01	<0.005	<0.02	<0.005	<0.001	0.013	<0.001	0.005	<0.02
	Median	<0.01	<0.005	<0.03	<0.005	<0.001	0.039	<0.001	0.009	0.030
	Max	<0.01	<0.01	0.025	0.005	<0.001	0.049	<0.001	0.010	0.042
2,3,4,7,8-PeCDF (pg/g)	Min	<0.01	<0.005	0.110	<0.004	<0.001	<0.01	<0.002	0.008	0.037
	Median	0.010	<0.01	0.120	<0.005	<0.001	<0.01	<0.002	0.008	0.042
	Max	0.010	<0.01	0.130	<0.006	0.001	0.049	<0.002	0.013	0.058
2,3,7,8-TCDF (pg/g)	Min	<0.003	<0.02	0.300	0.004	<0.001	0.047	<0.001	<0.04	<0.11
	Median	<0.004	<0.03	0.320	0.012	<0.001	0.078	<0.001	<0.04	<0.13
	Max	<0.01	0.036	0.400	0.016	<0.001	0.110	<0.001	<0.05	<0.2
OCDF (pg/g)	Min	<0.01	<0.01	<0.07	<0.04	<0.0003	<0.17	<0.0004	<0.007	<0.04
	Median	<0.01	<0.01	<0.08	<0.06	<0.0003	<0.20	<0.001	<0.01	0.18
	Max	<0.02	<0.03	<0.09	<0.06	<0.0003	<0.27	0.001	0.037	0.20

A 5.4 Free and bound 2-MCPD and 3-MCPD

Table A5.4.1. Concentrations of free and bound 2-MCPD and 3-MCPD in food groups in the Market Basket 2022 (N=3 samples per food group).

Compound		Cereal products	Pastries	Processed meat	Lean fish	Fatty fish	Meat substitutes	Plant-based drinks	Fats and oils	Potatoes	Sugar and sweets
Free 2-MCPD (µg/kg)	Mean	0	0	0	15	0	0	0	0	0	0
	Min	<5.0	<5.0	<5.0	14	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	Median	<5.0	<5.0	<5.0	15	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
	Max	<5.0	<5.0	<5.0	16	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Bound 2-MCPD (µg/kg)	Mean	0	30	0	15	0	19	0	46	0	0
	Min	<10	24	<10	15	<10	14	<10	35	<10	<10
	Median	<10	25	<10	15	<10	16	<10	40	<10	<10
	Max	<10	40	<10	15	<10	27	<10	62	<10	<10
Free 3-MCPD (µg/kg)	Mean	5.5	5.7	0	16	0	7.9	0	0	10	<5.0
	Min	5.1	5.7	<5	5.0	<5.0	7.9	<5.0	<5.0	5.4	<5.0
	Median	5.7	5.7	<5	16	<5.0	7.9	<5.0	<5.0	10	<5.0
	Max	5.8	5.7	<5	25	<5.0	7.9	<5.0	<5.0	15	<5.0
Bound 3-MCPD (µg/kg)	Mean	0	67	0	25	0	48	0	110	0	14
	Min	<10	53	<10	18	<10	35	<10	91	<10	11
	Median	<10	58	<10	25	<10	44	<10	94	<10	15
	Max	<10	90	<10	31	<10	65	<10	144	<10	16

< indicates a value below limit of quantification (LOQ). When calculating means as well as concentrations of vitamin A, D and K, medium bound concentration (0.5*LOQ) was imputed for non-detects, with exception for when all three samples in one food group had concentrations of an element below LOQ. In those cases, lower bound (0) was imputed for non-detects when calculation mean.

Appendix 6. Data used in the comparative risk characterization

Table A6.1. Reference values (RV), assessment factors (AF), severity category interval (C_{low} and C_{high}) and the associated critical effects used in the comparative risk characterization in the Market Basket 2022.

Compound	RV type[1]	RV	Unit per day	AF[2]	C_{low}[3]	C_{high}[3]	Critical effect[3]	Reference[4]
3-MCPD	TDI	2	µg/kg bw	1	2	3	renal effects	(EFSA, 2018b)
Aflatoxin B1	RP	400	ng/kg bw	100	4	4	increase of liver carsinomas	(EFSA, 2020b)
Aflatoxin tot	RP	400	ng/kg bw	100	4	4	increase of liver carsinomas	(EFSA, 2020b)
Acrylamide	RP	0.17	mg/kg bw	100	4	4	harderian gland adenomas and adenocarcinomas	(EFSA, 2015a)
Aluminum	TDI	143	µg/kg bw	1	3	3	development neurotoxicity	(EFSA, 2008b)
BBzP	TDI	500000	ng/kg bw	1	2	4	reproductive toxicity	(EFSA et al., 2019)
BDE-153	RP	3.2	ng/kg bw	10	3	4	neurodevelopmental effects (impaired learning and memory)	(EFSA, 2024b)
BDE-209 (1)[5]	RP	3000	ng/kg bw	10	3	3	reproductive effects (decrease sperm motility)	(EFSA, 2024b)
BDE-209 (2)[5]	RP	5000	ng/kg bw	10	3	4	neurodevelopmental effects (impaired learning and memory)	(EFSA, 2024b)
BDE-47 (1)[5]	RP	168	ng/kg bw	10	3	3	reproductive effects (impaired spermatogenesis)	(EFSA, 2024b)
BDE-47 (2)[5]	RP	1096	ng/kg bw	10	3	4	neurodevelopmental effects (impaired spatial learning and memory)	(EFSA, 2024b)
BDE-99 (1)[5]	RP	38.4	ng/kg bw	10	4	4	developmental effects (increased resorption rates in mated female offspring)	(EFSA, 2024b)
BDE-99 (2)[5]	RP	3575	ng/kg bw	10	3	3	neurodevelopmental effects (reduction in the level of anxiety)	(EFSA, 2024b)
Benzo(a)pyrene	RP	0.07		100	4	4	total tumours	(EFSA, 2008a)
Cadmium	TDI	0.36	µg/kg bw	1	2	2	change in kidney marker	(EFSA, 2009)
Calcium	LI	603	mg	1	1	1	calculated from AR based on replacement of calcium losses (CV: 10%)	(Blomhoff et al., 2023)

Compound	RV type[1]	RV	Unit per day	AF[2]	C_{low}[3]	C_{high}[3]	Critical effect[3]	Reference[4]
Calcium	UL	2500	mg	1	1	2	MAS hypercalcemia	(Blomhoff et al., 2023, EFSA, 2024a)
CB153	RP	7000	ng/kg bw	100	3	3	changes in liver and thyroid histopathology	(World Health Organization, 2016)
Copper	LI	494	µg	1	1	1	calculated from AR based on biomarkers (including plasma copper, serum ceruloplasmin and erythrocyte superoxide dismutase activity) (CV:15%)	(Blomhoff et al., 2023)
Copper	UL	5000	µg	1	1	2	retention of copper	(Blomhoff et al., 2023, EFSA, 2024a)
DDT-sum	TDI	10000		1	2	4	developmental toxicity	(JMPR, 2001)
Deoxynivalenol	TDI	1000	ng/kg bw	1	2	2	weight gain reduction	(EFSA, 2017b)
DINCH	TDI	1000000	ng/kg bw	1	2	3	renal effects	(EFSA, 2006)
DINP	TDI	150000	ng/kg bw	1	2	3	liver toxicity	(EFSA et al., 2019)
Dioxin-like compounds	TWI	0.286	pg/kg bw	1	3	3	reduced sperm quality	(EFSA, 2018a)
Ergotalkaloider	TDI	600	ng/kg bw	1	1	2	vasoconstrictive effects	(EFSA, 2012d)
Fluoride	LI	2.1	mg	1	1	1	calculated from provisional AR and AI based on reduction in risk of dental caries (CV: 12.5%)	(Blomhoff et al., 2023)
Fluoride (adults)	UL	120	mg	1	3	4	osteofluorosis	(EFSA, 2005c)
Folate	LI	177	µg DFE	1	1	1	calculated from AR based on biomarker (serum and red blood cell folate, plasma homocysteine) (CV: 15%)	(Blomhoff et al., 2023)
Folate	UL	1000	µg DFE	1	1	2	neurotoxicity in patients with B12-deficiency	(Blomhoff et al., 2023, EFSA, 2024a)
Fumonisiner	TDI	2000	ng/kg bw	1	2	3	liver toxicity	(EFSA, 2018c)
Glycidol	T25	10.2	mg/kg bw	250	4	4	neoplastic effects	(EFSA, 2016c)
HBCDD	RP	2350		10	3	3	neurodevelopmental effects on behaviour	(EFSA, 2021)
HCB (1)	TDI	170	ng/kg bw	1	2	3	hepatic effects	(World Health Organization/IPCS, 1997)

Compound	RV type[1]	RV	Unit per day	AF[2]	C_{low}[3]	C_{high}[3]	Critical effect[3]	Reference[4]
HCB (2)	TDI	160	ng/kg bw	1	4	4	cancer	(World Health Organization/IPCS, 1997)
Inorganic arsenic	RP	0.06	µg/kg bw	1	1	1	skin cancer	(EFSA et al., 2024a)
Iodine	LI	91	µg	1	1	2	calculated from provisional AR and AI based on urinary iodine associated with prevention of goitre (CV: 12.5%)	(Blomhoff et al., 2023)
Iodine	UL	600	µg	1	2	2	hormonal disturbance	(Blomhoff et al., 2023, EFSA, 2024a)
Iron	LI	6	mg	1	1	1	calculated from AR based on replacement of daily iron loss (CV: 15%)	(Blomhoff et al., 2023)
Iron	UL[6]	40000	mg	1	1	1	black stool	(EFSA, 2024a)
Lead (adults)[7]	RP	0.625	mg/kg bw	1	4	4	chronic kidney disease	(EFSA, 2010a)
Lead (developmental)[7]	RP	0.5	µg/kg bw	1	3	4	Neurotoxicity (reduced IQ)	(EFSA, 2010a)
Magnesium	LI	196	mg	1	1	1	calculated from provisional AR and AI based on observed intake (CV: 12.5%)	(Blomhoff et al., 2023)
Manganese	LI	1.8	mg	1	1	1	calculated from provisional AR and AI based on observed intake (manganese homeostasis)	(Blomhoff et al., 2023)
Manganese	UL[6]	8000	mg	1	3	4	neurotoxicity	(EFSA, 2024a)
Mercury	TDI	0.19		1	3	4	behavioural and motor disturbances	(EFSA, 2012e)
Molybdenum	LI	39	µg	1	1	1	calculated from provisional AR and AI based on observed intake, lower end (molybdenum homeostasis) (CV: 12.8% [CV=(RI/AR-1)/1.96])	(Blomhoff et al., 2023)
Molybdenum	UL	600	µg	1	3	4	reproductive toxicity	(Blomhoff et al., 2023) (EFSA, 2024a)
Nickel (acute)	TDI	4.3		1	1	1	Eczema	(EFSA et al., 2020a)
Nickel (chronic)[8]	TDI	13		1	4	4	post-inplantation loss	(EFSA et al., 2020a)
Ochratoxin A	RP	14500		100	4	4	increased combined incidences of adenomas and carcinomas	(EFSA, 2020c)

Compound	RV type[1]	RV	Unit per day	AF[2]	C_{low}[3]	C_{high}[3]	Critical effect[3]	Reference[4]
PAH4	RP	0.34	mg/kg bw	100	4	4	total tumours	(EFSA, 2008a)
PCA MCCP (C14-C17)	RP	36000	µg/kg bw	100	2	2	increased relative kidney weight	(EFSA et al., 2020b)
PCA SCCP (C10-C13)	RP	2300	µg/kg bw	100	3	3	incidence of nephritis in male rats	(EFSA et al., 2020b)
PFAS-4	TWI	0.63		1	2	3	reduced antibody response	(EFSA, 2020a)
Phosphorus	LI	317	mg	1	1	1	calculated from provisional AR and AI based on recommended calcium intake (molar ratio of calcium to phosphorus 1.4:1) (CV: 12.5%)	(Blomhoff et al., 2023)
Phosphorus	UL	3000	mg	1	2	3	nephrocalcinosis	(Blomhoff et al., 2023)
Potassium	LI	2114	mg	1	1	1	calculated from provisional AR and AI based on risk blood pressure and stroke risk (CV: 12.5%)	(Blomhoff et al., 2023)
Riboflavin	LI	1	mg	1	1	1	calculated from AR based on biomarker (CV: 10%)	(Blomhoff et al., 2023)
Selenium	LI	49	µg	1	1	1	calculated from provisional AR and AI based on biomarker (CV: 12.5%)	(Blomhoff et al., 2023)
Selenium	UL	255	µg	1	2	3	alopecia	(Blomhoff et al., 2023, EFSA, 2024a)
Silver	TDI	5.7	ng/kg bw	1	1	1	argyria	(World Health Organization, 2003)
Sodium	UL	2.3	g	1	4	4	Chronic disease risk reduction (CDRR), i.e. reductions in sodium intakes that exceed the CDRR are expected to reduce chronic disease risk within the general population.	(Blomhoff et al., 2023)
Thiamin	LI	0.04	mg/MJ	1	1	1	calculated from AR based on biomarker and erythrocyte transketolase activity coefficient (CV: 20%)	(Blomhoff et al., 2023)
Total T-2 and HT-2	TDI	100	ng/kg bw	1	2	2	reduction of total leukocyte count	(EFSA, 2017a)
Vitamin A (preformed)	UL	3000	RE	1	3	4	reproductive toxicity	(Blomhoff et al., 2023) (EFSA, 2024a)

Compound	RV type[1]	RV	Unit per day	AF[2]	C_{low}[3]	C_{high}[3]	Critical effect[3]	Reference[4]
Vitamin A	LI	413	RE	1	1	1	calculated from AR based on maintenance of liver stores (20 µg retinol/g liver) (CV: 15%)	(Blomhoff et al., 2023)
Vitamin D	LI	5.3	µg	1	1	1	calculated from AR based on biomarker (25(OH)D above 50 nmol/L) (CV: 15%)	(Blomhoff et al., 2023)
Vitamin D	UL	100	µg	1	1	2	hypercalcemia	(Blomhoff et al., 2023, EFSA, 2024a)
Vitamin E	LI	6	mg	1	1	1	calculated from AR based on basal requirement + prevention of PUFA oxidation (CV: 12.5%)	(Blomhoff et al., 2023)
Vitamin E	UL	300	mg	1	2	3	impaired coagulation	(Blomhoff et al., 2023, EFSA, 2024a)
Vitamin K	LI	42	µg	1	1	1	calculated from provisional AR and AI based on biomarkers (functional prothrombin, γ-carboxyglutamic acid) (CV: 12.5%)	(Blomhoff et al., 2023)
Zearalenon	TDI	250	ng/kg bw	1	2	2	oestrogenic activity	(EFSA, 2011)
Zinc	LI	7.52	mg	1	1	1	Calculated from AR based on zinc balance, accounting for absorption efficiency based on phytate intake (CV: 10%)	(Blomhoff et al., 2023)
Zinc	UL	25000	mg	1	1	1	copper deficiency	(Blomhoff et al., 2023, EFSA, 2024a)

AI, average intake; AR, average requirement; bw, body weight; LI, lower intake level; MAS, Milk-alkali syndrome; MJ, mega joule; RI, recommended intake; TDI, tolerable daily intake; UL, upper intake level.

[1] The LI was calculated as AR - 1.96*standard deviations (SD), where SD=AR*CV/100, and CV was derived from appendix 5 in the Nordic Nutrition Recommendation 2023 (Blomhoff et al., 2023). These LIs corresponds to an exposure that covers the requirement in 2.5% of the population, and under this approach it was not regarded motivated to use severity categories larger than C2.

[2] AF has generally been set to 100 in case a reference point (RP) based on experimental data was available rather than a TDI, or similar. In most cases the RP represents the lower confidence limit of a benchmark dose associated with a 10% increased response/incidence. For glycidol, AF was set to 250 since the RP represented T25 (a 25 % response). AF was set to 10 for HBCDD, BDE-47, BDE-99, BDE-209, and BDE-153 since the RP, based on animal data, in this case was translated to a chronic intake in humans. The AF = 10 was applied to account for sensitive individual, and to increase harmonization between the toxicological reference values used.

[3] The critical effect behind the RV was classified on a five graded severity scale, 1 to 5, according to a severity scoring system (Sand et al., 2018). In case of uncertainty about this judgement, the severity classification was allowed to span categories (C_{low} to C_{high}). The associated interval for the severity factor (assumed to be uniformly distributed) was then used in the calculations (see also Section 8.18). LIs were generally associated with a low severity category.

[4] References are found in section 11. References

[5] For PBDEs with two reference points (for different endpoints), the lowest was used in the risk ranking

[6] Safe level of intake. An UL was not set by EFSA due to insufficient data (EFSA, 2024a).

[7] For lead with two reference points, the one for adults was used in the risk ranking.

[8] For nickel with two reference points, the one for chronic effects was used in the risk ranking.

Appendix 7. Contributors to the Study and the Report

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[1] A=author, C=chemical analyses, PL=project leader, PG=project group, S=sample purchase and treatment. Figures refer to chapter.

Livsmedelsverket