



Mapping of dietary sources of nitrates and nitrites.

Part 1 of the risk assessment of nitrates and nitrites in food

Monica Hauger Carlsen, Monica Andreassen, Annette Bernhard, Ellen Bruzell, Tove Gulbrandsen Devold, Inger Therese Laugsand Lillegaard, Gro Haarklou Mathisen, Camilla Svendsen, Marcin W. Wojewodzic, Eva Denison, Berit Granum, Trine Husøy

Scientific Opinion of the Panel on Food Additives, Flavourings, Processing Aids, Materials in Contact with Food, and Cosmetics of the Norwegian Scientific Committee for Food and Environment

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Part 1 of the risk assessment of nitrates and nitrites in food

Preparation of the report

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed a project group to draft the report. The project group consisted of VKM members and VKM staff. The Panel on Food Additives, Flavourings, Processing Aids, Materials in Contact with Food, and Cosmetics assessed and approved the final report. (VKM et al., 2024)

Authors of the report

The authors have contributed to the report in a way that fulfils the authorship principles of VKM (VKM, 2019). The principles reflect the collaborative nature of the work, and the authors have contributed as members of the project group and/or the VKM Panel on Food Additives, Flavourings, Processing Aids, Materials in Contact with Food and Cosmetics.

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The assessment and approval followed VKM's routine for approving risk assessments (VKM, 2018).

Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third-party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

Nitrates and nitrites are naturally present in a variety of foods and are authorised as food additives within the EU. Nitrates and nitrites have been linked to both positive and negative health effects (Ma et al., 2018). There is no overview of foods containing nitrates and nitrites on the Norwegian market and the occurrence of these substances in food. The intake of nitrates and nitrites among different population groups in Norway is unknown.

The Norwegian Food Safety Authority has requested the Norwegian Scientific Committee for Food and Environment (VKM) to assess whether nitrates and nitrites from food may pose a health risk to any population group in Norway. The purpose of the current mapping of dietary sources, as the first part of the assignment, was to provide an overview of food products containing nitrates and/or nitrites on the Norwegian market. This included identifying foods containing nitrates and/or nitrites, the concentrations of these substances in these food items and the food intake. In the second part of the assignment, this overview will be used to assess whether the total dietary intake from nitrates and nitrites constitutes a health risk for the Norwegian population.

A pragmatic approach was applied to create the overview:

- One database (VetDuAt) was used to identify products on the Norwegian market containing nitrates and/or nitrites. The listing of food items in this database is comprehensive but not exhaustive.
- One database (EuroFIR; European Food Information Resource Network), three reports from the European Food Safety Authority (EFSA), and an Australian survey of nitrates and nitrites in food and beverages were used to identify the occurrence data on nitrates and nitrites in food.
- Intake data were sourced from a national dietary survey conducted among Norwegians aged 18-80 (Norkost 3).

VKM found that products from most food groups contain nitrates and/or nitrites. These substances are present in various beverages, fruit, vegetables, potatoes, legumes, grains and grain products, meat, fish, milk and milk products, butter, margarine and oils, salt and spices as well as in composite dishes based on these ingredients and in infant food. There are large differences in the amount of nitrate and nitrite found within each food group. This overview also shows in which food groups information on nitrate and nitrite content were lacking.

VKM identified food items and food groups for which either occurrence, intake, or both were high, as assessed by expert judgement, and thus may be important contributors to the exposure. According to WHO (2016), the main dietary sources of nitrates and nitrites are plant-based foods, mainly leafy vegetables and some root vegetables, cured meat, some cheese products, cereals, plant-based dietary supplements, and drinking water and water-based beverages. Except for drinking water, which was not included in this first part of the risk

assessment and plant-based dietary supplements for which occurrence data were not found, we identified the same dietary sources as listed by WHO to be potentially important contributors to nitrate and nitrite in the Norwegian diet.

The exposure assessment for different Norwegian population groups and various dietary patterns, will be estimated in part 2 of the risk assessment of nitrates and nitrites. The second part will also include the estimated contribution to the total exposure of nitrates and nitrites from specific food groups.

Key words: E 249, E 250, E 251, E 252, food additives, natural occurrence, plant extract, vegetable extract.

Sammendrag på norsk

Nitrater og nitritter finnes naturlig i en rekke matvarer og er godkjent for bruk som tilsetningsstoffer i EU. Nitrat og nitritt har vært knyttet til både positive og negative helseeffekter (Ma et al., 2018). Det finnes ingen oversikt over hvilke matvarer på det norske markedet som inneholder nitrat og nitritt, eller hvor mye de inneholder. Det er heller ikke kjent hvor mye nitrat og nitritt ulike befolkningsgrupper i Norge får i seg fra kostholdet.

Mattilsynet har gitt Vitenskapskomiteen for mat og miljø (VKM) i oppdrag å vurdere om nitrat og nitritt fra mat kan utgjøre en helserisiko for en eller flere grupper i den norske befolkningen. Det overordnede formålet med kartleggingen, den første delen av oppdraget, var å lage en oversikt over matvarer på det norske markedet som inneholder nitrat og/eller nitritt. Dette omfattet å identifisere matvarer som inneholder nitrat og/eller nitritt, hvor mye matvarene inneholder av disse stoffene og hvor mye som spises av de enkelte matvarene. Denne oversikten skal deretter brukes i del 2 til å vurdere om det totale inntaket av nitrat og nitritt utgjør en helserisiko for den norske befolkningen.

Det ble brukt en pragmatisk tilnærming i arbeidet med å lage oversikten:

- Det ble brukt en database (VetDuAt) for å identifisere nitrat- og/eller nitrittholdige produkter på det norske markedet. Denne databasen er omfattende, men inneholder ikke alle matvarer på det norske markedet.
- Det ble brukt en database (EuroFIR; European Food Information Resource Network), tre rapporter fra den europeiske myndighet for næringsmiddeltrygghet (EFSA), samt en australsk rapport for å identifisere hvor mye nitrat og nitritt ulike matvarer inneholder.
- Konsumdata for voksne ble hentet fra en nasjonal kostholdsundersøkelse som inkluderer nordmenn i alderen 18-80 år (Norkost 3).

VKM fant at produkter fra de fleste matvaregrupper inneholder nitrat og nitritt, enten hver for seg eller sammen. Stoffene finnes i ulike drikkevarer, fisk, frukt, grønnsaker, belgvekster, poteter, kjøtt, korn og kornprodukter, melk og melkeprodukter, salt og krydder, smør, margarin og oljer, samt i spedbarnsmat og sammensatte retter. Det er store forskjeller i mengden nitrat og nitritt som er funnet i de ulike matvaregruppene. Oversikten viser også i hvilke matvaregrupper som var merket å inneholde nitrat/nitritt eller planteekstrakter, men hvor vi ikke fant informasjon om konsentrasjoner.

Matvarer som kan være viktige kilder til nitrat/nitritt i norsk kosthold ble vurdert basert på konsentrasjoner og mengde spist. Ifølge WHO (2016) er plantebasert mat, hovedsakelig bladgrønnsaker og noen rotgrønnsaker, drikkevann og vannbaserte drikker, spekemat, noen osteprodukter, frokostblandinger og plantebaserte kosttilskudd de viktigste kildene til nitrat og nitritt i kosten. Med unntak av drikkevann (var ikke inkludert i denne oversikten) og

plantebaserte kosttilskudd, hvor det ikke ble funnet data på nitrat/nitritt-innhold, ble de samme matvaregruppene identifisert å være potensielle viktige bidragsyttere til nitrat og nitritt i det norske kostholdet.

Hvor mye nitrat og nitritt den norske befolkningen får i seg fra kostholdet, skal beregnes i den neste delen av risikovurderingen av nitrat og nitritt. Denne vil omfatte ulike befolkningsgrupper og ulike kostholdsmønstre, og matvarer som er viktige bidragsyttere til det totale inntaket vil bli identifisert.

Abbreviations and glossary

Abbreviations

EFSA European Food Safety Authority

FAIR Findability, Accessibility, Interoperability, and Reuse of data

NLP Natural language processing

FNN Food Nitrate and Nitrite Database

Glossary

The “At a glance” database

An overview of a selection of foods that may be important contributors to nitrate and/or nitrite exposure, containing information about occurrence of nitrates/nitrites in the selected foods and intake of the selected foods. The intake is based on the average intake estimates from the national dietary survey Norkost 3 which included adults (18-70 years).

Exposure

In this mapping the term exposure is used for nitrate and/or nitrite, and it is defined as the amount of nitrate and/or nitrite an individual has ingested through diet.

FAIR

FAIR is an abbreviation for Findability, Accessibility, Interoperability, and Reuse of data. The principles emphasise machine-actionability (i.e., the capacity of computational systems to find, access, interoperate, and reuse data with none or minimal human intervention) because humans increasingly rely on computational support to deal with data because of the increase in volume, complexity, and creation speed of data (go-fair.org/fair-principles/).

Fuzzy string-matching

Fuzzy string-matching is an artificial intelligence technique that identifies similar, but not identical elements in a data set. The Levenshtein algorithm is an example of a fuzzy string-matching method.

Food item

The term “food item” refers to a single type of food, often in its natural state such as an apple or a chicken breast filet. It is often not, or minimally processed, and does not comprise of several ingredients.

Foods

The term “foods” in the present report includes food items and beverages in general, not focusing on single or special food items.

FoodEx2

FoodEx2 is a standardised system for classifying and describing food used by The European Food Safety Authority ([Food classification standardisation – The FoodEx2 system | EFSA \(europa.eu\)](https://www.efsa.europa.eu/en/food-ex2)).

Intake

In this mapping the term intake describes the amount of a food item/food group consumed by a person through their diet.

KBS

A food, energy and nutrient database and calculation system (“**KostBeregningsSystem**”; University of Oslo).

Levenshtein distance algorithm

A technique used in natural language processing that looks for similarities between a word and a given text. The Levenshtein distance algorithm calculates a number that reflects how similar two words are. The higher the number, the more similar the two words are.

Medium bound scenario

In the medium bound scenario, data below the limit of detection (left-censored data) are substituted by half the limit of detection.

NLP

Natural language processing (NLP) is a subfield of artificial intelligence that uses machine learning to enable computers to process human written and oral language.

Occurrence data

In this mapping the term occurrence data describes data that gives information about the amount of a substance in foods or food items.

Ontology

A set of concepts and categories in a subject area or domain (here foods or substances) that shows their properties and the relations between them.

Background as provided by the Norwegian Food Safety Authority

Nitrate and nitrite can be converted into potentially carcinogenic substances, such as certain nitrosamines. This can happen both during the processing of products containing these substances and in the digestive tract following intake. The European Food Safety Authority (EFSA) has established acceptable daily intakes (ADIs) for nitrate and nitrite. The intake of nitrate and nitrite among different population groups in Norway is unknown, and no records of nitrate- and nitrite-containing foods exist.

Nitrate and nitrite can both be added or occur naturally in a food. For example, several types of meat products are added nitrate and/or nitrite for preservation. The substances inhibit the growth of bacteria, including *Clostridium botulinum*, which can form the toxic substance botulinum toxin. Several food plants have a natural content of nitrate.

The Nordic dietary guidelines ([NNR23](#)) and the current Norwegian dietary guidelines ([Helsedirektoratet 2024](#)) recommend a higher intake of fruit and vegetables than the previous Norwegian dietary guidelines from 2012. The Norwegian Food Safety Authority needs to know whether any future increases in the intake of fruit and vegetables in the Norwegian population may affect the intake of nitrate and nitrite.

An overview of which foods contain nitrate and nitrite, and what the population consumes, will give the Norwegian Food Safety Authority the opportunity to plan monitoring and control programs and be able to provide relevant advice to consumers.

Terms of reference as provided by the Norwegian Food Safety Authority

With this assignment to the Norwegian Scientific Committee for Food and Environment (VKM), the Norwegian Food Safety Authority wants to ascertain whether exposure to nitrate and nitrite can pose a health risk to one or more groups in the Norwegian population. The Norwegian Food Safety Authority also aims to gain a comprehensive overview of which foods contain nitrate and nitrite.

The assignment is divided into two parts. The first part will contain an overview of foods that contain nitrate and nitrite. The Norwegian Food Safety Authority will use this overview to select which foods will be included in future monitoring and control programmes. The second part will address exposure estimations for nitrate and nitrite from food for different groups in the Norwegian population. The exposure estimations will provide the basis for health risk assessments in the population groups.

Part 1

The Norwegian Food Safety Authority asks VKM to provide an overview of foods containing nitrate and nitrite, both naturally occurring and from addition.

Part 2

The Norwegian Food Safety Authority asks VKM to:

- Assess whether there is a need to update the Acceptable Daily Intakes (ADIs) for nitrate and nitrite.
- Calculate exposure to nitrate and nitrite in the Norwegian population.
- Include a scenario that covers recommendations in the Norwegian dietary guidelines from 2024.

Assess the risk of negative health effects.

1 Introduction

1.1 Nitrates and nitrites in foods

Nitrates and nitrites are inorganic nitrogen-containing substances found in the environment, mostly in soil, water, and in many foods (EFSA, 2008; EFSA et al., 2017a; EFSA et al., 2017b; Luetic et al., 2023). Bound to different minerals they form water soluble salts used in fertilizers, they accumulate in the food chain in vegetables and fruits, cereals and in products of animal origin (EFSA, 2008; EFSA et al., 2017a; EFSA et al., 2017b; Luetic et al., 2023), and also occur in specific varieties of seaweed (Martín-León et al., 2021). They can occur naturally in plant produce, be deliberately added to food as food additives or in the form of plant (including vegetable) extracts (Figure 1.1-1).

Potassium nitrite E 249, sodium nitrite E 250, sodium nitrate E 251 and potassium nitrate E 252 are added as food preservatives in food of animal origin. As a secondary effect, these additives may also impact sensory properties such as appearance (colour) and flavour. The use of these food additives is restricted by Regulation (EC) No 1333/2008 on food additives (Regulation (EC) No 1333/2008). The Regulation (EU) No 231/2012 (EU, 2012) lays down specifications for all food additives listed in Annexes II and III to Regulation (EC) No 1333/2008.

Plant extracts containing nitrates and nitrites may be added to food items. However, the use of extracts that perform a technological function (i.e. preservation effects) in the final product is regarded as deliberate use as food additive, and the food additive legislation shall apply (EC, 2018).

Maximum levels of nitrate are set in specified foods in the Regulation (EC) No 2023/915 on maximum levels for certain contaminants in food (EU, 2023) (not yet implemented in Norwegian law, where Regulation (EC) No 1881/2006 still applies (EU, 2006)).

The main dietary sources of nitrate and nitrite are plant-based foods, mainly leafy vegetables and some root vegetables, drinking water, water-based beverages, cured meat, some cheese products, cereals, and plant-based dietary supplements (WHO, 2016).

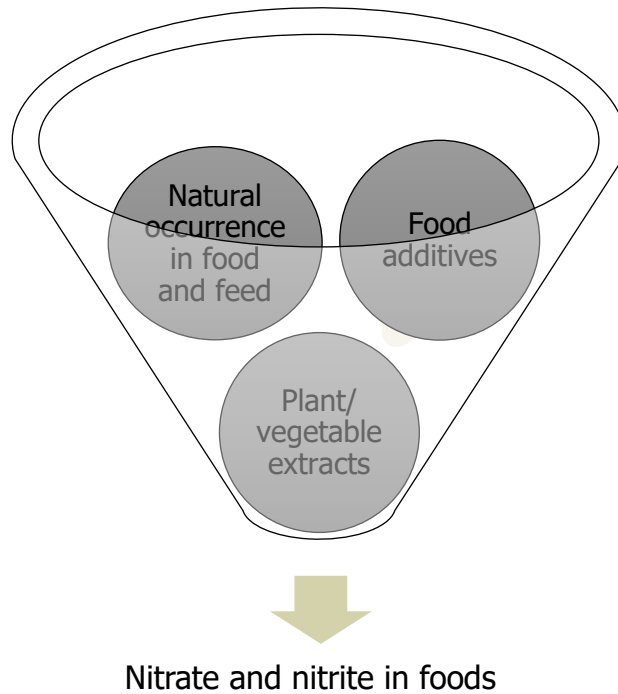


Figure 1.1-1. An overview of the food origins of nitrates and nitrites included in the current report.

1.2 Nitrates and nitrites in the body

Whereas sources to human nitrate exposure are mainly exogenous, sources to nitrite exposure are mainly endogenous (Luetic et al., 2023). Nitrate and nitrite have been linked to both positive and negative health effects (Ma et al., 2018). In the body, the salivary glands actively concentrate dietary and endogenously produced nitrate from plasma. Salivary nitrate is partly converted to nitrite by oral commensal bacteria (Lundberg and Weitzberg, 2013). Both nitrate and nitrite can be absorbed in the gastrointestinal tract and enter the circulatory system. Nitrites formed endogenously are also concentrated in salivary glands and recirculated into the gastrointestinal tract. Nitrite may contribute to the formation of nitrosamines, some of which are carcinogenic, either directly in the presence of gastric acid in the stomach or in reactions catalysed by bacteria (Lundberg and Weitzberg, 2013). Nitrites may also oxidize haemoglobin to methaemoglobin, which in excess reduces the ability of the red blood cells to bind to and transport oxygen throughout the body (Lundberg and Weitzberg, 2013). With regard to physiological effects, studies suggest that nitrate intake from vegetables confers health benefits, particularly through the association with an improved endothelial function and reduction in blood pressure (Kotopoulou et al., 2021). On the contrary, other research supports a link between processed foods, particularly meat products and nitrate and nitrite intakes from these, and elevated risk of cancer in the gastrointestinal tract (Lundberg and Weitzberg, 2013; Kotopoulou et al., 2021).

1.3 Aim

The aim was to prepare a comprehensive overview of food items containing nitrates and nitrites in the Norwegian diet, based on all dietary sources, thus including food items containing nitrates/nitrites resulting from natural accumulation through the food chain, food additives, and plant extracts.

1.4 Delimitations

The overview of foods is restricted to:

- Plant produce and animal-based foods that naturally contain nitrate and/or nitrite, such as vegetables.
- Food items to which nitrate and/or nitrite is added as additive potassium nitrite (E 249), sodium nitrite (E 250), sodium nitrate (E 251), and potassium nitrate (E 252)), such as cured meat.
- Food items with added plant (including vegetable) extracts that may naturally contain nitrates and/or nitrites.

Drinking water is not included in this first part of the risk assessment of nitrates and nitrites in foods but will be included in the risk assessment (part 2).

The intake data for adults (Norkost 3) are included in this first part of the risk assessment of nitrates and nitrites, intake data for all age groups will be included in the risk assessment (part 2).

The searches in the Norwegian commercial VetDuAt database were limited to the search terms in Table 2.1.3-1.

2 Materials and methods

A selection of databases and publications was used to identify food items containing nitrates and/or nitrites (Section 2.1). Data were charted from these databases and publications and compiled in a new database (an Excel file) and named the "Food Nitrate and Nitrite Database" (FNN database). The following information is included in the FNN database (when available): food name and food group, substance(s) analysed in the food, means of processing, occurrence data and intake data.

The food, energy and nutrient database and calculation system KBS (University of Oslo) was applied to group the compiled food items (Section 2.2). The KBS food composition database is an extended version of the Norwegian food composition table (matvaretabellen.no).

The quantities and frequencies of intake of food groups containing nitrate and nitrite within the general Norwegian diet (Section 2.3) were retrieved from the national dietary survey Norkost 3 (Totland et al., 2012).

2.1 Identification of foods containing nitrate and/or nitrite

2.1.1 Publications with occurrence data

Data were extracted from four reports containing summary of occurrence data and/or reported use levels on nitrites and/or nitrates in food (Table 2.1.1-1).

Table 2.1.1-1. Overview of the four reports and extracted data included in the database.

Report	Extracted data	Reference
Re-evaluation of sodium nitrate (E 251) and potassium nitrate (E 252) as food additives	Summary data of analytical results of nitrates (E251-252) and nitrates from other sources (natural presence or contamination) in foods that were reported by the member states in the EU. Summary of the reported use levels of food additive nitrates (E251-252) provided by industry.	(EFSA et al., 2017a)
Re-evaluation of potassium nitrite (E 249) and sodium nitrite (E 250) as food additives	Summary of the reported use levels (mg/kg or mg/L as appropriate) of potassium and sodium nitrite (E 249–250) provided by industry and of analytical results (mg/kg) of potassium and sodium nitrite (E 249–250) provided by member states.	(EFSA et al., 2017b)
Nitrate in vegetables – Scientific Opinion of the Panel on Contaminants in the Food chain	Summary data of analytical results of potassium and sodium nitrite (E249-250) provided by member states in the EU.	(EFSA, 2008)

Report	Extracted data	Reference
Survey of nitrates and nitrites in food and beverages in Australia	Analytical results for nitrate and nitrite in 52 food items on the Australian market.	(FSANZ, 2011)

2.1.2 Database with occurrence data

The EuroFIR food database ([European Food Information Resource](http://eurofir.org)) is an international, member-based, non-profit association under Belgian law set up in 2009 to ensure sustained advocacy for food information in Europe (eurofir.org). One of the resources provided by EuroFIR is the online tool "FoodEXplorer", which contains food composition data from national food composition databases in the European Union Member States as well as in the USA and Canada. We conducted targeted searches for foods in the FoodEXplorer database to identify food containing nitrates, nitrites and nitrosamines using the food component identifiers "NITRA", "NITRI" and "NITRN", respectively. The searches in FoodEXplorer were conducted in June 2024 and search results were extracted in Excel files.

2.1.3 Database without occurrence data

The commercial food information database 'VetDuAt.no' is a Norwegian database with information about brand level food items and their ingredients. The database contains information such as food item name, nutrient content, and the list of ingredients. It is not a food composition database and does not include information about the amount of nitrates and nitrites in foods. VKM used a snapshot of this database obtained in Excel format from the creators at VetDuAt.no (dated 30.05.2024), including 71497 foods. The purpose of extracting data from the VetDuAt database was to identify and obtain information about food items on the Norwegian market to which nitrate and/or nitrite were added either as additives or as plant extracts. The database was also used to identify foods naturally containing nitrates and nitrites, such as celery and spinach. The database includes foods from manufacturers in Norway as well as imported products. However, food items from some brands (e.g. First Price, Jacobs, Eldorado, Fersk&Ferdig, Fiskemannen, Folkets and Rema 1000) were not part of this database at the time of data extraction.

All preprocessing and extraction of data were performed using Python 3.0 (see Abbreviations and glossary for expressions in this section). We utilized packages in the Python library, such as Pickle, Pandas, Re, CSV, to load, read, and reformat file content. To identify the four food additives and other information in the ingredient lists of the food items in the database, the Fuzz package was used to look for similarities between text and indicated keywords, utilizing the fuzzy string-matching technique. A comprehensive, simplified flow chart illustrating the extraction strategy used is given in Figure 2.1.3-1. During the extraction, different elements were introduced to gain both sensitivity and specificity of the search.

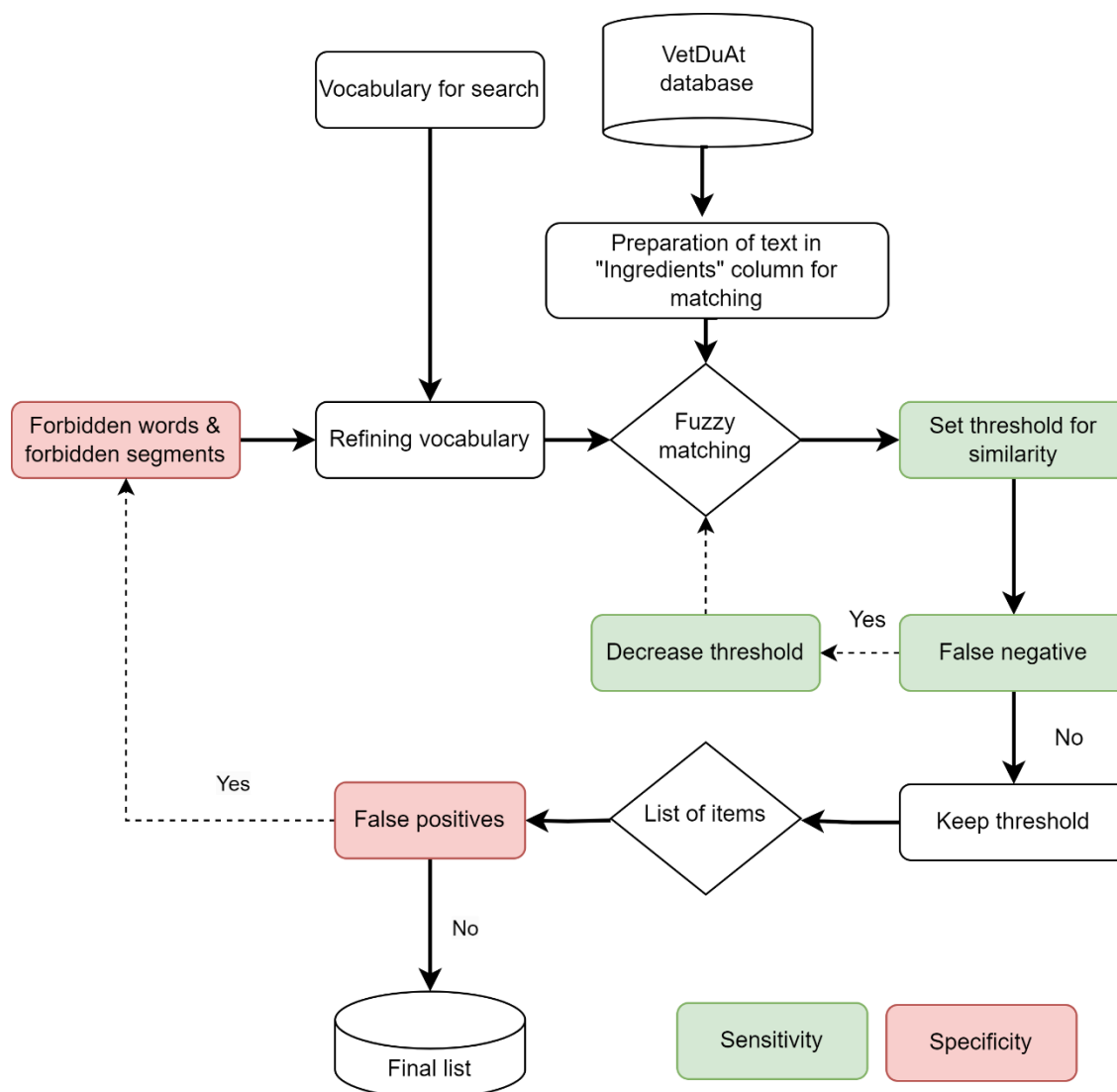


Figure 2.1.3-1. Flow chart illustrating extraction strategy from the VetDuAt database. Elements are introduced to gain sensitivity (shown in green), and specificity (shown in red). Threshold for similarity is especially important to gain additional sensitivity, however a dictionary with forbidden words and segments is crucial for specificity.

We used fuzzy string-matching with the Levenshtein distance algorithm to identify similar, but not identical elements in the data. This technique was employed to capture similar words, especially when words were misspelled, or punctuation was introduced. The Python code was designed to extract, process, and analyse information from the database, using fuzzy string-matching technique, focusing on certain food additives (e.g., nitrates, nitrites), foods that are known for having high occurrence of naturally occurring nitrates and nitrites, as well as vegetable extracts. In line with the FAIR principles, the Python code is publicly available in the GitHub repository '<https://github.com/bazylyszek/VKM-001-nitrit-nitrate>' with AGPL-3.0 license, and archived at Zenodo: '<https://doi.org/10.5281/zenodo.14253302>', with the DOI: 10.5281.

Preprocessing of columns for search

The text in the ingredients lists was prepared for fuzzy string-matching to extract food items containing nitrites, nitrates, or specific food items as specified below. The column titled 'ingredients content' (Norwegian: 'ingredienser') was used for extraction. Since this column contains strings of multiple words, certain symbols (i.e.: ')', '^', '%', '_', ']', '\') were stripped from the text prior to processing as they are unrelated to the ingredient names they would be found next to. Other symbols (i.e.: ',', '(', ':', '\', '[', ';', '{') were treated as separators, dividing two ingredient names as they were the ones most likely to be followed by other characters. To further increase sensitivity (the number of items matched and discovered), we ran the search twice, once in which it divided the ingredients list on only the separators mentioned above, and once where it also divided them on spaces between individual words in addition to the mentioned characters (Figure 2.1.3-1). This approach increases sensitivity of the search.

Definition of Keywords

Based on expert knowledge a set of Norwegian keywords were first identified and used in the searches (Table 2.1.3-1) before they were supplemented with common variants of these keywords due to the discovery of both alternative spellings and common spelling errors in the VetDuAt database (see Table 2.1.3-1, Figure 2.1.3-1).

Table 2.1.3-1. Terms used to identify food containing nitrates and/or nitrites defined prior to the search, and additional terms (marked in *italic*) that were appended during the search, that were not present in the original protocol.

Substance	Search terms in English	Search terms in Norwegian
Nitrates	<ul style="list-style-type: none"> • Ammonium nitrate bicarbonate • Chile saltpeter • Chilean nitrate • E 251 • E 252 • Niter • Nitrate • Nitrate of potash • Potassium nitrate • Saltpeter • Soda niter • Sodium nitrate 	<ul style="list-style-type: none"> • Ammoniumnitrat bikarbonat • E 251 • E 252 • Kaliumnitrat • Niter • Nitrat • Nitrat av kaliumklorid • Salpeter • Natriumnitrat
Nitrites	<ul style="list-style-type: none"> • E 249 • E 250 • Nitrite • Nitrous acid, potassium salt • Nitrous acid, sodium salt 	<ul style="list-style-type: none"> • E 249 • E 250 • Nitritt • Kaliumnitritt • Natriumnitritt

Substance	Search terms in English	Search terms in Norwegian
	<ul style="list-style-type: none"> • Potassium nitrite • Sodium nitrite 	<ul style="list-style-type: none"> • <i>Nitritsalt</i>
Nitrates and/or nitrites	<ul style="list-style-type: none"> • Vegetable extract • Plant extract • Botanical extract • Herbal extract • Veggie extract • Vegetable broth • Phyto extract • Plant essence • Vegetable essence • Plant concentrate • Vegetable concentrate • Vegetable tincture • Plant-derived extract 	<ul style="list-style-type: none"> • Grønnsaksekstrakt • Planteekstrakt • Urteekstrakt • Grønnsaksbuljong • Fytoekstrakt • Planteessens • Grønnsaksessens • Plantekonsentrat • Grønnsakskonsentrat • Grønnsakstinktur
Nitrates and/or nitrites	<ul style="list-style-type: none"> • Spinach • Celery • Rucola • Lettuce • Cabbage • Beetroot • Seaweed 	<ul style="list-style-type: none"> • Spinat • Selleri • Rucola • Salat • Kål • Rødbete • Tare • <i>Kvitkål</i> • <i>Rødtkål</i> • <i>Hodekål</i> • <i>Grønnskål</i> • <i>Stangselleri</i> • <i>Sellerirot</i>

Word matching and extraction strategy

We created the function ``matchesAnyIndex`` that returns the index of all elements in the VetduAt database containing an ingredient that fuzzy matched at least one of the provided keywords. During extractions, different fuzzy cutoffs were tested to determine the optimal word similarity threshold, of which 100 is a total match and 0 is no match. Cutoffs of 95 and 80 were applied and compared for sensitivity of the search strategy (Figure 2.1.3-1). Results were further manually curated by inspecting false positives in the search result to further improve accuracy (Figure 2.1.3-1). The 'no-spaces' version was able to find complex key phrases such as 'vegetable extract' while the spaces version was able to pick up cases where the nitrate/nitrite related key word was part of a larger phrase or had additional words such as 'preservative' appended to it.

The code saved excel files containing only the rows with at least one keyword/name for nitrate/nitrite/extracts/food, as well as additional columns showing the matched keyword and how strongly it was associated with the closest word in the table.

During extraction, certain terms that should not be matched were identified and omitted in the code (see Table 2.1.3-2). This approach automatically excluded any content with a forbidden segment, even if it only partially matched the search terms. Similarly, any item that exactly matched a forbidden word was also excluded. For example, 'salat' (English: "salad") would match 'salt,' so 'salt' was added as an excluded word to prevent mismatches. However, if 'salt' was in the forbidden segments, it would block matches like 'nitritsalt.' By placing 'salt' in the forbidden words section, it only excluded the exact word 'salt' but not 'nitritsalt'.

Additionally, special handling was implemented for E numbers due to inconsistencies in their recording in the database (e.g., 'konserveringsmiddel,' 'middel,' 'konserveringsmiddel-E,' 'E-', etc.), which could lead to missed matches.

Finally, we refined our search using the created function '*compareIndex*' to assess the impact of further lowering the fuzzy matching cutoffs (70, 60) which was compared to the high cutoffs (95, 80) to assess additional gain of lowering this cutoff (Figure 2.1.3-1). In this way we could assess whether lowering the cutoff had an additional gain or only contributed to noise in the search.

Table 2.1.3-2. List with excluded elements (segments in the words or words) during extraction process (words in Norwegian).

Element type excluded	List of defined items during reciprocal search
Forbidden segments	sitr, sellerifrø, kålrabi, kålrot, løk, vin, benzoat, citrat, selenit, løl, tøk, læk, løg, lök, kaliumiaktat, natriumlaktrat, salter
Forbidden words	salt, salter, ammoniumbikarbonat, KALIUMBITARTRAT, ammoniumnitrat bikarbonat, natriumsistrat, natriumsitater, natriumtartrat, eller, HVITLO, hvitlø, ananaskonsentrat, beteekstrakt, eple konsentrat, epleekstrakt, eplekonsentrat, eple konsentrat, eplekonsetrat, Eplekonsentrat, erteekstrakt 1, gjæreekstrakt, grønnte sekstrakt, grønnteeekstrakt, /gæreekstrakt, /epleekstrakt, jæreekstrakt, KANELEKSTRAKT, kanelekstrakt*, kanelekstrakt, lønneekstrakt, mynteeekstrakt, smaksekstrakt, østerekstrakt, pæreekstrakt, pærekonsentrat, rekeekstrakt, roseekstrakt, teekstrakt, teekstrakt*, teekstrakter, tekonsentrat^, gæreekstrakt, gærsekstrakt, rødbeterød, /Gulrotsekstrakt, beteekstrakt, erteekstrakt, grønnteeekstrakt, grønnteeekstrakt*, gulrotekstrakt, plommekonsentrat, proteineekstrakt, tre, Spianata

Visualization

We used open source Draw.io software (drawio.com) to visualise the logic behind the Python code for data extraction of foods from the VetDuAt database. The flowchart (Figure 2.1.3-1) illustrates this logic.

We used an online tool at wordcloud.com to visualise some of the extracted foods (Figure 3.3-1). This tool counts occurrence of identical words and plots them with different font size corresponding to counts. Quantitative information provided together with the market name of products (i.e. weight, portion, unit) was removed to reduce noise in this visualisation.

We utilized the open source Venny2 tool (bioinfogp.cnb.csic.es/tools/venny/) to produce three different Venn diagrams to visualize counts of food items in the following comparisons:

1. Food items in the VetDuAt database with added nitrates (E 251, E 252) ('Nitrates') or nitrites (E 249, E 250) ('Nitrites') as food additives, alone or in combination (Figure 3.1-2).
2. Food items in the VetDuAt database with added nitrates (E 251, E 252) ('Nitrates') or nitrites (E 249, E 250) ('Nitrites') as food additives, and plant produce or animal-based foods that naturally contain nitrate and/or nitrite ('Foods'), alone or in combination (Figure 3.1-3).
3. Food items in the VetDuAt database with added nitrates (E 251, E 252) ('Nitrates') or nitrites (E 249, E 250) ('Nitrites') as food additives, plant produce and animal-based foods that naturally contain nitrate and/or nitrite ('Foods'), and food items with added plant (including vegetable) extracts that may naturally contain nitrates and/or nitrites, alone or in combination (Figure 3.1-4).

Overviews of the foods belonging to each of the categories illustrated in the Venn diagrams (Figures 3.1-2, 3.1-3, 3.1-4) were produced and deposited as Excel files in Zenodo, under following link <https://doi.org/10.5281/zenodo.14253302> and GitHub <https://github.com/bazylyszek/VKM-001-nitrit-nitrate>'.

2.2 The compiled food and nitrate/nitrite data

The compiled nitrate and nitrite data were organized and categorized in the following manner in the FNN database: First, all relevant data in the reports EFSA et al. 2017a and b, EFSA et al. 2008, FSANZ, 2011, and the EuroFIR database were collected and included in one datafile. All original information from each database was kept unchanged for reference, even if the naming and information were not similarly presented in the different data sources. Second, the food grouping system in KBS was used to assigned foods to a main food group according to the 17 main food groups of KBS. Examples on food groups in KBS are "Meat and meat products", "Milk and dairy", "Vegetables", "Grain and grain products", and "Fruit, berries and nuts". Third, subcategories were added to some food groups to improve the overview of the database and facilitate necessary detailed categorization.

2.3 Intake data for foods that contain nitrate/nitrite

Intakes of food groups in gram per person per day were extracted from the national dietary survey Norkost 3 (Totland et al., 2012). The national dietary survey Norkost 3 was conducted

by the University of Oslo in collaboration with the Norwegian Directorate of Health. Norkost 3 assessed diet using two 24-hour recall phone interviews at least one month apart. Food amounts were presented in household measures or estimated from photographs (Totland et al., 2012). The study was conducted in 2010/2011, and 1787 men and women aged 18-70 years participated.

2.4 Selection of foods that may be important contributors to nitrate and/or nitrite exposure (from the FNN database)

VKM extracted data from the FNN database (Supplementary materials 1, sheet 2), to create a smaller dataset highlighting food items that we consider as potential important contributors to the total nitrate and nitrite exposure (Supplementary materials 1 sheet 1 ("At a glance") and Table 3.5-1). The selection was made by expert judgement based on the following criteria:

- The food items are relevant for the Norwegian diet based on intake information from the Norkost 3 survey (Totland et al., 2012)

OR

- High occurrence of nitrates and/or nitrites

The dataset contains the following entries: food group, name of the food item, food intake (according to Norkost 3), occurrence of nitrates and/or nitrites in the food item, and the total number of samples.

3 Results

Occurrence data were obtained for nitrate and/or nitrite in foods on the European, Australian, and the Japanese markets. All compiled data are included in the Supplementary materials 1. The European data constitute the basis for this report and for the selection of foods that may be important contributors to nitrate and/or nitrite exposure.

The result section is structured as follows:

- Section 3.1: An overview of the occurrence data for nitrates and nitrites in foods.
- Section 3.2: An overview of the estimated intakes of nitrate- and nitrite-containing foods.
- Section 3.3.: An overview of foods on the Norwegian market containing nitrates and/or nitrites.
- Section 3.4.: An overview of foods on the Norwegian market that were identified to contain nitrate/nitrite or plant (including vegetable) extracts, for which European occurrence data were not identified.
- Section 3.5: A selection of foods assessed to have high occurrence of nitrates and/or nitrites and/or considered to be associated with high intake.

The FNN database contains the following data: occurrence data for nitrate and/or nitrite in foods, the intake of the nitrate- and/or nitrite-containing foods, foods on the Norwegian market with identified content of nitrates and/or nitrites either as food additives or natural content, and food items with added plant (including vegetable) extracts that may naturally contain nitrates and/or nitrites (Supplementary materials 1). The 13 sheets of the file provide the following information:

- **Sheet 0 "Information"**. Guidance on the contents of the database.
- **Sheet 1 "Database at a glance"**. A selection of foods that may be important contributors to nitrate and/or nitrite exposure. The selected foods are considered to contain higher levels of nitrates/nitrites (based on the median medium-bound and the mean medium-bound scenario) and/or considered as having high intake levels.
- **Sheet 2 "The FNN Database, all foods compiled"**. All identified European occurrence data for nitrates and/or nitrites in foods. The data are presented as they were reported in the original data source. The sheet is a combination of sheets 3-6.
- **Sheet 3 "Nitrates, EFSA 2017"**. Occurrence data compiled from EFSA Opinion, 2017.
- **Sheet 4 "Nitrates, EFSA 2008"**. Occurrence data compiled from EFSA Opinion, 2008.
- **Sheet 5 "Nitrites, EFSA 2017"**. Occurrence data compiled from EFSA Opinion, 2017.
- **Sheet 6 "EuroFIR"**. Occurrence data compiled from the EuroFIR database.
- **Sheet 7 "Nitrates and nitrites, FSANZ 2011"**. Occurrence data compiled from this Australian report FSANZ, 2011.
- **Sheet 8 "Nitrates, VetDuAt"**. Food items on the Norwegian market added nitrate as food additive (E 251, E 252), identified in the commercial Norwegian database VetDuAt.

- **Sheet 9 "Nitrites, VetDuAt "**. Food items on the Norwegian market added nitrite as food additive (E 249, E 250), identified in the commercial Norwegian database VetDuAt.
- **Sheet 10 "Extracts, VetDuAt "**. Food items on the Norwegian market with added plant (including vegetable) extracts that may naturally contain nitrates and/or nitrites, identified in the commercial Norwegian database VetDuAt.
- **Sheet 11 "Foods, VetDuAt "**. Plant produce and animal-based foods that naturally contain nitrate and/or nitrite, identified in the commercial Norwegian database VetDuAt.
- **Sheet 12 "Abbreviations"**. Abbreviations used in the database.
- **Sheet 13 "Glossary"**. Explanation of terms used in the database.

3.1 European occurrence data for nitrates and nitrites in foods

The occurrence data for nitrate were reported as "nitrates" (EuroFIR, EFSA 2008), "nitrates (E 251-252) and nitrates from other sources (natural presence or contamination)" (EFSA, 2017a). The occurrence data for nitrite were reported as "nitrites" (EuroFIR), and "nitrites (E 249-250) and nitrites from other sources (natural presence or contamination)" (EFSA, 2017b).

Data were found for the following food groups: "beverages", "butter, margarine, oil", "composite dishes", "fish", "fruit", "grain and grain products", "infant foods", "legumes", "meat", "milk and dairy products", "potato", "salt and spices", and "vegetables". Occurrence data for nitrates were available for one or more food items in all the food groups. Occurrence data for nitrites were available for one or more food items in all food groups except "butter, margarine, oil" and "legumes". An overview of the compiled European occurrence data is presented in Table 3.1-1. Data from the medium bound scenario are included in this table, all scenarios included in the EFSA opinions are available in the Supplementary materials 1 (sheet 2 (European data); sheets 3-7 present the data collected from each report/database). In the medium bound scenario, data below the limit of detection (left-censored data) are substituted by half the limit of detection.

Table 3.1-1. An overview of the European occurrence data for nitrates and/or nitrites in food (EFSA et al., 2008; EFSA et al., 2017a; EFSA et al., 2017b; EuroFIR). LC: Left-censored (i.e., the data point is below the limit of detection). % LC: The percentage of the analytical data below the limit of detection. Medium bound scenario: Data below the limit of detection (left-censored data) are substituted by half the limit of detection. N: Number of samples. -: No European data identified.

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
Beverages	Tea and herbs for infusions (Solid)	6	16.7	1315	1161.7	1	100	5	5
	Soft drinks	27	3.7	13.4	13.0	4	75	0	0
	Non-alcoholic beverages (excepting milk-based beverages)	3	66.7	10	11.4	2	100	0	0
	Alcoholic beverages	37	0	7.8	9.8	1	100	0	0
	Drinking water	3909	41.2	2.4	7.9			-	-
	Tea (infusion)	1	100	0	0			-	-
	Beer and beer-like beverage			-	-	1	0	33.6	33.6
	Drinking water (water without any additives except carbon			-	-	985	86.4	0	0

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	dioxide; includes water ice for consumption)								
Butter, margarine, oil	Margarine and similar products	1	0	4.1	4.1			-	-
	Animal fat	1	100	1	1			-	-
Composite dishes	Vegetable products	15	6.7	430	1232.1	3	100	5	7.5
	Composite food (including frozen products)	4	0	31.2	42.4	30	0	8.3	9.4
	Ready to eat soups	14	1	129	124.3			-	-
	Sauerkraut	24	0	180.5	186.7			-	-
	Savoury sauces	1	0	16.4	16.4			-	-
	Vegetable-based meals	2	0	114.9	114.9			-	-
Fish and seafood	Herring (Clupea)	3	0	30.2	37.7			-	-
	Eels (Apodes)	1	0	9.9	9.9			-	-
	Fish meat	1	100	9.5	9.5			-	-

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Fish products	2	50	10.8	10.8			-	-
	Mackeral (Scomber)	6	0	6.2	9.4			-	-
	Salmon and trout (Salmo spp.)	29	3.5	4.9	10.5			-	-
	Whitefish (Coregonus)	2	0	13.9	13.9			-	-
	Fish and other seafood (including amphibians, reptiles, snails and insects)			-	-	24	80	2	4.3
Fruit	Apple			-	*Mean= 29 mg/kg			-	*Mean=3 mg/kg
	Fruit juice	14	7.1	16	22.7			-	-
	Mixed fruit juice	4	50	13.3	15.8			-	-
	Mixed vegetable juice	2	0	27.1	27.1			-	-
	Concentrated fruit juice			-	-	1	100	0	0
	Fruit and fruit products			-	-	19	84.2	0.8	2.9

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Fruit nectar			-	-	1	100	0	0
Grain and grain products	Bread and rolls	4	75	7.5	91.4			-	-
	Breakfast cereals	12	66.7	11.4	18.2			-	-
	Grains as crops	17	41.2	4.9	6.4			-	-
	Grains for human consumption	90	25.6	15.5	23.1			-	-
	Pasta	24	0	64.8	65.1			-	-
	Rice-based meals	1	100	26.5	26.5			-	-
	Grains and grain-based products			-	-	20	95.2	0	0.8
Infant food	Cereal-based food for infants and young children	497	35.2	22.9	22	95	71.6	0.4	2.8
	Food for infants and small children	524	28.8	35.7	46.8	5	60	6.7	7.5

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Follow-on formulae, powder	8	12.5	28.3	36.5	2	100	0.3	0.3
	Follow-on formulae, liquid	14	78.6	25	30.4			-	-
	Fruit purée for children	224	32.6	22	28.4	91	96.7	0.5	0.7
	Fruit juice and herbal tea for infants and young children	17	23.5	20.3	53.1	2	0	17.2	17.2
	Infant formulae, liquid	2	50	44.8	44.8			-	-
	Infant formulae, powder	7	42.9	5.4	8.5	2	0	0.5	0.5
	Ready-to-eat meal for infants and young children	145	43.5	25	38.3	19	84.2	0.5	2.3
	Ready-to-eat meal for	49	77.6	25	24.3	4	25	13.9	12.8

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	children, cereal-based								
	Ready-to-eat meal for children, meat and vegetables	420	31.4	25	37.1	93	72	0.5	3.8
	Ready-to-eat meal for children, meat/fish-based	163	15.3	31.0	39.7	18	77.8	0.2	3.1
	Ready-to-eat meal for children, vegetable-based	1103	36.9	29	45.7	92	82.6	0.5	0.9
Legumes	French beans	52		*Median=20	*Mean=756			-	-
	Beans	48		*Median = 435	*Mean = 392			-	-
	Green beans	362		*Median = 293	*Mean = 323			-	-
	Green beans			-	*Mean = 250			-	-
	Peas	407		*Median = 1	*Mean = 30			-	-
	String beans	610		*Median = 610	*Mean = 618			-	-
	Corned beef	87	13.79	37.2	66	68	15.0	21	32.7

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
Meat *15 products with the highest mean medium bound scenario	Meat and meat products (including edible offal)	1	0	119.3	119.3	33	42.4	6	32
		106	21.7	19.5	57.4			-	-
	Edible offal, farmed animals			-	-	3	20.0	8.7	24.6
	Pastrami, pork			-	-	32	10.0	15.3	22.9
	Bacon	910	6.04	36	53	82	18.8	11.5	22.3
	Cooked smoked sausage	214	0.47	51.6	52.9	19	8.8	17.2	20.4
	Preserved poultry			-	-	5	10.6	13.3	16.2
	Luncheon meat			-	-	1	12.5	4.9	14.3
	Fresh and lightly cooked sausage			-	-	40	16.3	9.3	14.2
	Ham, turkey			-	-	0	0.0	6.4	13.0
	Cooked sausage	278	3.24	47.45	50.9	35	12.1	6.6	11.7
	Poultry			-	-	14	42.4	6.7	11.6

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Preserved meat			-	-	261	36.9	6.7	11.5
	Meat specialities			-	-	17	12.1	5.7	11.5
	Uncooked smoked sausage			-	-	81	24.4	4.7	10.7
	Corned beef			-	-			-	-
	Game mammals	4	0	58	64.6			-	-
	Mutton / lamb meat (Ovis aries)	2	0	61.3	61.3			-	-
	Pork, dried	102	37.25	36.9	54.9			-	-
	Edible offal, farmed animals	57	3.51	23	51.7			-	-
	Pork / piglet meat (Sus scrofa)	144	13.19	29	44.7			-	-
	Beef, dried	22	40.91	28.8	44.6			-	-
	Ham, beef	24	25	29.9	44.3			-	-
	Semi-dry sausage	35	2.86	47	43.8			-	-
	Ham, pork	824	16.63	27.1	42.4			-	-

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
Milk and dairy products	Yoghurt, cheese and milk-based dessert for infants and young children	8	37.5	53.0	63.9			-	-
	Ice cream and desserts	1	0	51.5	51.5	2	100.0	3.3	3.3
	Whey and whey products (excluding whey cheese)	1	0	30.0	30.0			-	-
	Cheese	348	14.08	16.1	19.9	185	24.3	3.9	7.7
	Liquid milk	41	87.8	1	5.3	7	85.7	0.2	0.2
	Fermented milk products			-	-	2	100.0	0.0	0.0
Potato	Main-crop potatoes	414	0.97	150	167.1			-	-
	Potatoes and potato products	361	16.34	148	165.1			-	-
	New potatoes	126	4.76	136.7	145.1			-	-
	French fries	26	0	108.5	103.7			-	-

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Potato boiled	2	50	38.1	38.1			-	-
	Potato-based dishes	2	0	33.8	33.8			-	-
	Potato Average			-	*Mean = 87			-	*Mean = 4.1
Salt and spices	Seasoning or extracts	28	17.86	482.3	448.0	23	8.7	564.9	784.0
	Herbs	275	3.27	1156.0	1470.9	1	100.0	5.0	5.0
	Spices	2	0	1515.0	1515.0			-	-
	Flavourings or essences	1	0	212.0	212.0			-	-
	Herbs, spices and condiments	1	0	198.0	198.0			-	-
	Condiment	12	0	53.6	53.2			-	-
Sugar and sweets	Molasses and other syrups	12	0	6.6	7.1			-	-
	Confectionery (non-chocolate)			-	-	2	0	0	0
Vegetables Nitrate: 15 products with the highest mean	Rocket, Rucola (Eruca sativa, Diplotaxis spec.)	1927	1.4	4440	4301.6	89	94.4	1.5	1.4

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
medium bound scenario	Purslane (Portulaca oleracea)	9	0	3527	4106.6			-	-
	Cardoons (Cynara cardunculus)	6	0	3114	3134.8			-	-
	Stem vegetables (Fresh)	4	0	3056.5	2957.5	4	75.0	1.5	1.2
	Leaves and sprouts of Brassica spp (Brassica spp.)	20	5	2350	2506.6			-	-
	Vine leaves (grape leaves) (Vitis euvtis)	1	0	2479	2479			-	-
	Lamb's lettuce (Valerianella locusta)	544	0.18	2333	2288.7			-	-
	Water cress (Nasturtium officinale)	5	0	1613	1728.3			-	-
	Beet leaves (Beta vulgaris)	395	5.32	1561	1716.6	4	100.0	0.4	0.4

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Turnips (Brassica rapa)	15	6.67	1652	1630.6			-	-
	Lettuce, excluding Iceberg-type lettuce (Lactuca sativa)	5727	5.83	1331	1532.8			-	-
	Spinach (fresh) (Spinacia oleracea)	2790	6.74	1350	1491.5	42	88.1	1.3	4.2
	Leaf vegetables	445	2.02	1135	1472.9	10	100.0	9.3	9.3
	Garden orache (Atriplex hortensis)	25	0	1520	1428			-	-
	Beetroot (Beta vulgaris subsp. vulgaris)	476	0.21	1015	1320.6			-	-
	Brassica vegetables			-	-	1	100.0	12.5	12.5
	Fruiting vegetables			-	-	14	100.0	12.5	11.4

Food (as reported in the original source)		Nitrates				Nitrites			
		N	% LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)	N	%LC	Median medium bound scenario (mg/kg)	Mean medium bound scenario (mg/kg)
	Lettuce, excluding Iceberg-type lettuce (Lactuca sativa)			-	-	90	95.6	1.5	9.5
	Iceberg-type lettuce			-	-	19	89.5	0.5	7.7
	Spinach (Spinacia oleracea), preserved, deep-frozen or frozen			-	-	99	64.7	1.7	5.7
	Root vegetables			-	-	55	94.6	0.4	1.7
	Bulb vegetables			-	-	2	100.0	1.5	1.5
	Starchy roots and tubers			-	-	350	88.9	1.5	1.4
	Sugar plants			-	-	3	100.0	0.6	0.6

*Median / mean; not medium bound scenario.

A selection of food items assessed by VKM to have high content of nitrates and/or nitrites are presented in Section 3.5 and Supplementary materials 1 (sheet 1).

3.2 Intake data for food groups containing nitrates and nitrites

All foods were assigned to a main food group according to the KBS system (see Appendix I for an overview of the main food groups in the KBS system). Dietary data from the national dietary survey Norkost 3 (Totland et al., 2012) were used to estimate the average absolute intakes of food groups (in gram per day) by adults which were further recalculated into percentages of total intake (Table 3.2-1, adapted from the intake estimates of Table 7 in the Norkost 3 survey (Totland et al., 2012)). The food groups milk and dairy products, cereals, fruit and berries, vegetables, and meat and meat products were among the solid food groups with the highest average absolute intakes.

Table 3.2-1. Approximate average absolute intakes estimated for the KBS food groups (all foods included), shown as percentage of the total intake. The intake estimations are based on Norkost 3 (all adults).

Food group		Approximate average intake food groups (g/day), in Norkost 3 (% of total intake)
Milk and dairy products, excluding butter		10
Grain and grain products		7
Fruit and berries		5
Vegetables		4
Meat and meat products		4
Fish and fish products		2
Potatoes and potato products		2
Butter, margarine, vegetable oils		1
Egg		1
Sweets and snacks		1
Beverages	All	60
	<i>Water</i>	<i>29</i>
	<i>Coffee</i>	<i>14</i>
	<i>Soda</i>	<i>7</i>
	<i>Tea</i>	<i>5</i>
	<i>Alcoholic beverages</i>	<i>4</i>

3.3 Food items in the VetDuAt database containing nitrates and/or nitrites

The commercial food information database VetDuAt was used to identify foods containing nitrates and/or nitrites on the Norwegian market. The ingredient lists of all the food items in the database were searched for keywords. Of the 71497 food items in VetDuAt, the following were identified:

- 531 foods with ingredient declarations including the terms "nitrate", "nitrates", "E 251" or "E 252".
- 4135 foods with ingredient declarations including the terms "nitrite", "nitrites", "E 249" or "E 250".
- 1707 plant produce and animal-based foods naturally containing nitrate and/or nitrite.
- 403 food items added plant extracts that may naturally contain nitrates and/or nitrites.

All the identified food items are included in the FNN database (Supplementary materials 1, sheets 8, 9, 10, and 11).

Among the foods with added nitrate listed in the FNN database (sheet 8), 152 cheeses were identified. These included products from large-scale dairies, small artisanal producers, and imported brands. Notably, some of the most familiar brands of Norwegian cheeses, such as "Norvegia" and "Jarlsberg" produced by TINE, are absent from this list, as they are made without the use of nitrate.

Most of the foods in the VetDuAt database were composite foods and dishes, and it is not always obvious which ingredient(s) contains nitrate and/or nitrite. Figure 3.3-1 is an attempt to illustrate this, where the word-cloud represents 19 food items added plant extracts that may contain nitrates and nitrites and added the food additive nitrite. The 19 food items include club sandwiches with fillings, where neither the sandwich itself, nor the egg contains nitrate and nitrite, but the sandwich ingredients bacon and chorizo do.



Figure 3.3-1. Word-cloud representing the Norwegian words used in the brand names of the 19 food items added plant extracts that may naturally contain nitrates and added nitrite as food additive. An overview of the food items can be found in Zendo under the following link: <https://doi.org/10.5281/zenodo.14253302> .

An overview of the number of foods in the VetDuAt database with ingredient declarations including the terms nitrate(s), nitrite(s), E 249, E 250, E 251, or E 252 (“Nitrates”, “Nitrites”), alone or in combination, is shown in Figure 3.3-2. Figure 3.3-3 gives an overview of the number of plant produce and animal-based foods naturally containing nitrate and/or nitrite (“Foods”) in addition to the foods shown in in Figure 3.3-2, alone or in combination. Figure 3.3-4 gives an overview of the number of foods with added plant extracts that may naturally contain nitrates and/or nitrites (“Extracts”) in addition to the foods shown in Figure 3.3-3, alone or in combination.

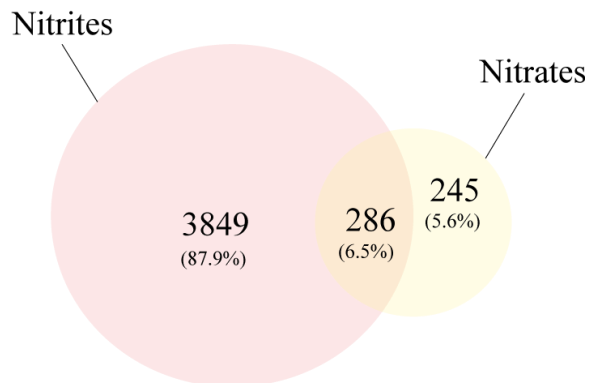


Figure 3.3-2. The number of food items added either nitrate (E 251, E 252; pink; “Nitrates”), nitrite (E 249, E 250; yellow; “Nitrites”), or both (pink/yellow), identified in the commercial Norwegian food information database VetDuAt (n=4380). Percentages denote the relative proportion of each entity (note:

the total number of foods in VetDuAt: n= 71497). An overview of the food items can be found in Zendo under the following link: <https://doi.org/10.5281/zenodo.14253302> .

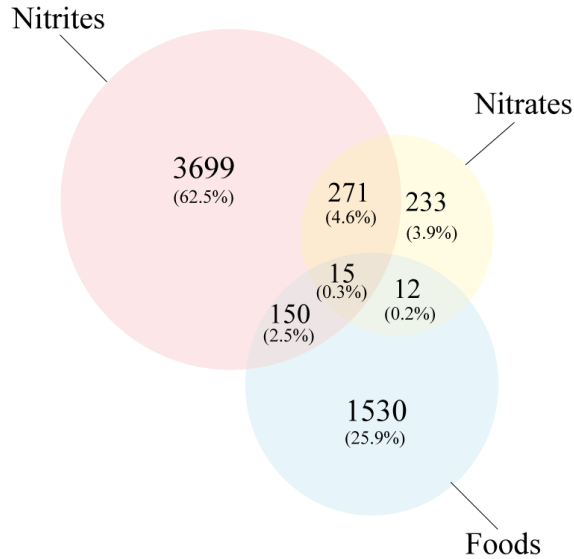


Figure 3.3-3. The number of food items naturally containing nitrate and/or nitrite (blue; "Foods"), foods added either nitrate (E 251, E 252; pink; "Nitrates") or nitrite (E 249, E 250; yellow; "Nitrites"), or combinations of these, identified in the commercial Norwegian food information database VetDuAt (n=5910). Percentages denote the relative proportion of each entity (note: the total number of foods in VetDuAt: n= 71497). An overview of the food items can be found in Zendo under the following link: <https://doi.org/10.5281/zenodo.14253302> .

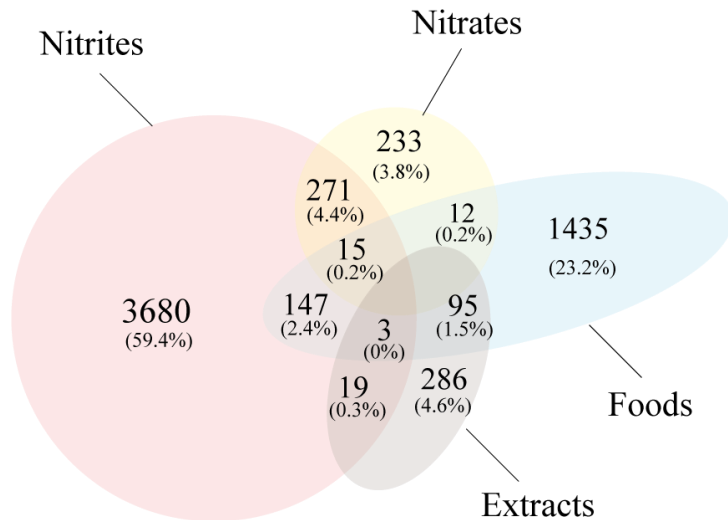


Figure 3.3-4. The number of food items naturally containing nitrate and/or nitrite (blue; "Foods"), foods added either nitrate (E 251, E 252; pink; "Nitrates"), nitrite (E 249, E 250; yellow; "Nitrites"), plant

extracts that may naturally contain nitrates and/or nitrites ("Extracts"), or combinations of these, identified in the commercial Norwegian food information database VetDuAt (n=6196). Percentages denote the relative proportion of each entity (note: the total number of foods in VetDuAt: n= 71497). An overview of the food items can be found in Zendo under the following link: <https://doi.org/10.5281/zenodo.14253302> .

In the VetDuAt food information database 12 food items contained both nitrate as a food additive and naturally occurring nitrate (Foods). In addition, 15 food items contained both nitrate and nitrite as food additives as well as naturally occurring nitrate (Foods).

A total of 403 entries in VetDuAt database included some type of extract from plants (herbs or vegetables) in the ingredients list. For 286 of the entries, plant extracts were the only identified source to nitrate/nitrite. There was a large diversity in food items with added extracts, from sweets and ice cream to chicken filets and baked beans. The dominant food group consisted of chocolate and sweets.

Ninety-five entries in the VetDuAt database had both some type of extract or concentrate from plants in the ingredients list, in addition to being a plant produce or animal-based food that naturally contained nitrate and/or nitrite. There was a large variation of food items in this group, including composite dishes with, meat, fish and chicken, vegetables, condiments and sweets.

Nineteen entries contained both nitrites and extracts. The common foods in this group were cured and/or smoked meat.

Only three entries that were added nitrites as a food additive, had some type of extract or concentrate from plants, in the ingredients list, in addition to being a plant produce or animal-based food that naturally contained nitrate and/or nitrite. These were pâtés of goose and duck and a ready-made vegetable soup.

3.4 Nitrate- and/or nitrite containing food items on the Norwegian market that lack occurrence data

Vegetable-based dietary supplements were identified in VetDuAt to contain nitrates. No occurrence data for nitrates and nitrites in dietary supplements were identified.

Foods with added plant extracts or concentrates that may naturally contain nitrates and/or nitrites are available on the Norwegian market (Figure 3.3-4). Occurrence data for such extracts were not identified.

3.5 Foods that may be important contributors to nitrate and/or nitrite exposure

The total intake of nitrate/nitrites from the diet is dependent on the occurrence of the substances in the food and the frequency and amount of intake. For example, a food item high in nitrate is not an important source of nitrate if it is seldom eaten. Likewise, a food that has moderate to low nitrate occurrence may be an important dietary source of nitrate if eaten frequently and in high amounts. A selection of the food items/food groups, assessed by expert judgement to may be important dietary sources of nitrates and/or nitrites, are shown in Table 3.5-1. An extended version is available in Supplementary materials 1, sheet 1.

Expert judgement is based on the same criteria as the 'At a glance' table in the FNN database: i) occurrence data were available from one or more source (database or report), and ii) the food item was relevant in terms of the Norwegian diet based on intake information from the Norkost 3 survey, or iii) the occurrence was considered to be in the higher level. The assessment of the level of occurrence is based on Table 3.1-1 and Supplementary materials 1 sheet 2. The assessment of the relevance of the food item for the Norwegian diet is based on the data presented in Table 3.2-1. In addition, the Norwegian Food Based Dietary Guidelines (Helsedirektoratet, 2016) have been considered in this evaluation, as both increased and decreased intake of specific food groups may warrant special attention from the Norwegian Food Safety Authority regarding dietary nitrate and nitrite sources.

Table 3.5-1 Foods that may be important contributors to nitrate and/or nitrite exposure. The selection of food group and/or food items that may be important contributors to nitrate and/or nitrite exposure are based on expert judgement. The medium bound scenario occurrence data are presented. Consumers are the percentage of the Norkost 3 (Totland et al., 2012) participants reporting intake of the food item. -: No European occurrence data were identified.

Food group	Food item	Nitrates Median / mean (mg/kg)	Nitrites Median / mean (mg/kg)	Consumers (%) [*]	Mean intake (g/day)	Median intake (g/day)
Beverages	Beer	-	33.6 / 33.6	15 ^a	553	313
Fish	Herring	30.3 / 37.7	-	5	34	30
Fruit	Fruit juice	16 / 22.7	-	48	224	200
Grain and grain products	Bread and rolls	7.5 / 91.4	-	99	173	154
	Breakfast cereals	11.4 / 18.2	-	28	56	
	Pasta	64.8 / 65.1	-	28 ^b	37	32
Legumes	Beans	*435 / 392	-	7	17	12
Meat	Bacon	36 / 53	11.5 / 22.3	13	25	20
	Cooked sausage	47.5 / 50.9	6.6 / 11.7	25 ^c	71	57

Food group	Food item	Nitrates Median / mean (mg/kg)	Nitrites Median / mean (mg/kg)	Consumers (%)*	Mean intake (g/day)	Median intake (g/day)
	Cooked, smoked sausage	51.6 / 52.9	17.2 / 20.4	25 ^c	71	57
	Pastrami, pork	-	15.3 / 22.9	na ¹	na	na
	Pork, dried	36.9 / 54.9	-	7	21	18
Milk and dairy products	Cheese	16.1 / 19.9	3.9 / 7.7	87	45	36
Potato	Main-crop potatoes	150 / 167.1	-	66	100	
	Potatoes and potato products	148 / 165.1	-	66	100	85
Vegetables	Carrot	57.3 / 121.9 (*125 / 296)	-	46	50	34
	Rocket, Rucola (Eruca sativa, Diplotaxis spec.)	4440 / 4301.6	1.5 / 1.4	7	40	25
	Stem vegetables (fresh)	3056.5 / 2957.5	1.5 / 1.2	16 ^d	31	24
	Spinach (fresh) (Spinacia oleracea)	1350 / 1491.5	1.3 / 4.2	2,1	100	68
	Leaf vegetables	1135 / 1472.9	9.3 / 9.3	46 ^e	27	20

*Persons reporting intake of the food.

^aAlcoholic beer is included.

^bBoth dried and cooked pasta weights are included.

^cAll sausages are included.

^dKohlrabi and leek are included.

^eAll salads with green leaves are included.

¹No available intake data.

4 Discussion

4.1 Identification of occurrence data

The Norwegian Scientific Committee for Food and Environment (VKM) applied a pragmatic approach to identify occurrence data of nitrates and/or nitrites in food. Aside from the data sources mentioned in the Method section, no systematic searches were performed to identify additional relevant data sources. A more comprehensive approach may have resulted in the identification of additional occurrence data.

4.2 Matching occurrence data with food intake

The intake estimates provided facilitate the identification of food items that may be important contributors to nitrate and/or nitrite dietary exposure in the Norwegian adult population. Identification of food items that may be important contributors to nitrate and/or nitrite exposure for other age groups will be included in the next part of this risk assessment (part 2). The accuracy in the identification of intake of nitrate and/or nitrite containing foods depended on the level of details available in the dietary intake data of specific food items, and the level of details available in the occurrence data. For some food groups included in the present report, the occurrence data was less detailed than the intake data. This may have introduced some uncertainties in our estimations and the overall evaluation of high- and low-level food groups.

Identification of food items that may be important contributors to nitrate and/or nitrite exposure for other age groups will be included in the next part of this risk assessment (part 2).

4.3 Identification of food items in the VetDuAt database

VKM applied a pragmatic approach to identify nitrate- and/or nitrite-containing food items/food groups on the Norwegian market. The VetDuAt database, containing more than 70 000 food items from different brands on the Norwegian market, was the only source used for this purpose. VetDuAt does not cover all food items on the Norwegian market (see Introduction). Despite these limitations, VKM considers that a representative 'snapshot' of the main nitrate and/or nitrite foods present on the Norwegian market today has been identified. However, we cannot exclude a possible bias in our search due to missing brands. Use of other food information databases with more brands may have resulted in the identification of additional food items.

Another limitation of our search strategy for foods that naturally contained nitrate and/or nitrite, was the influence by prior knowledge. As a result, we may have omitted food items, such as carrots, from the search, which we later discovered contained nitrate and/or nitrite. Nevertheless, we identified more than 6000 food items on the Norwegian market containing nitrates and/or nitrites (Supplementary materials 1).

In addition to the non-standardised wording of the ingredients column in the VetDuAt database, the same type of product may have been included several times for different product sizes, e.g., the same type of cheese or ketchup may appear several times with different product numbers due to different packaging sizes. This resulted in duplication

of the items in FNN database. VKM notes that a more stringent way of describing the ingredients in the ingredient lists, i.e. precise use of word and descriptions, or introducing ontology concepts, would facilitate both an overview of food item ingredients and further analyses of the ingredients found in foods, if implemented. Furthermore, the ontology concept for food items could be built based on the composition of food items, i.e., ingredients and their quantitative information, rather than the market name of the food item.

4.4 Foods that may be important contributors to nitrate and nitrite exposure

According to WHO (2016), the main dietary sources of nitrate are plant-based foods, mainly leafy vegetables and some root vegetables, drinking water, water-based beverages, cereals and plant-based dietary supplements. The corresponding nitrite sources are cured meat and some cheese products. Apart from drinking water, which was not included in part 1 of the risk assessment of nitrates and nitrites, and plant-based dietary supplements, for which no occurrence data identified, these food groups are included in Table 3.5-1. The degree of contribution of these dietary sources to the total exposure, for different population groups and dietary patterns, will be estimated in part 2 of the risk assessment of nitrates and nitrites.

Infant foods occurrence data were considered to be relatively high, but since this population group is not included in Norkost 3, intake data were not included in this report. However, intake estimates for this population group will be included in the risk assessment (Part 2). Since occurrence data for nitrates/nitrites in plant-based dietary supplements were not identified, VKM sees the need to obtain such data to estimate the degree of contribution to the total exposure to nitrates and/or nitrites from such supplements for Norwegian adults.

4.5 Conclusion

In the present overview of foods containing nitrates and nitrites on the Norwegian market, VKM found that products from most food groups contain nitrate and/or nitrite. The substances are found in various beverages, fish, fruit, vegetables, legumes, potatoes, meat, grains and grain products, milk and milk products, salt and spices, butter, margarine and oils, as well as in infant food and composite dishes. There are large differences in the amount of nitrate and nitrite found in the various food groups.

VKM noted gaps in occurrence data for food items that may be important contributors to the total nitrate and/or nitrite in the Norwegian diet. Next, this overview will be used in a risk assessment of nitrate and nitrites for the Norwegian population.

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Appendix I

The 17 main food groups in KBS are as follows:

- Grain and grain products
- Potatoes
- Vegetables -dishes and -products
- Fruit, berries, nuts, and seeds
- Meat and meat products
- Fish, fish products and shellfish
- Egg
- Milk and dairy
- Margarine, oil, mayonnaise, dressing
- Chocolate, sweets, deserts, ice cream, sweet, breadspread
- Beverages
- Composite dishes and products
- Spice and salt
- Infant food
- Dietary supplements
- Ungrouped
- Diverse products