EXTERNAL SCIENTIFIC REPORT

Food of plant origin: production methods and microbiological hazards linked to food-borne disease.

Reference: CFT/EFSA/BIOHAZ/2012/01 Lot 2
(Food of plant origin with low water content such as seeds, nuts, cereals, and spices)

Evelyn Hackl\textsuperscript{a}, Alexandra Ribarits\textsuperscript{b}, Nives Angerer\textsuperscript{b}, Markus Gansberger\textsuperscript{b}, Christine Hözl\textsuperscript{a}, Cornelia Konlechner\textsuperscript{a}, Jutta Taferner-Kriegl\textsuperscript{b}, Angela Sessitsch\textsuperscript{a}

\textsuperscript{a}: AIT Austrian Institute of Technology GmbH, Bioresources Unit
\textsuperscript{b}: Austrian Agency for Health and Food Safety GmbH (AGES)

ABSTRACT

Food-borne diseases caused by food of non-animal origin (FoNAO) contaminated with pathogenic bacteria, viruses and parasites are a major health concern worldwide. The present study was set up as an extensive literature review aimed at evaluating biological hazards associated with FoNAO with low water content. Data were extracted from 315 publications to identify the most critical FoNAO/pathogen combinations. The number and severity of outbreaks of disease provided the basis for a primary evaluation, and qualitative criteria relating to pathogen prevalence, food/pathogen interaction, and the production of FoNAO items were used for defining three priority groups. Level one priority worldwide was assigned to “seeds for sprouting and sprouted seeds” in combination with both \textit{Salmonella} spp. and pathogenic \textit{E. coli}, respectively. Priority two was attributed to rice/\textit{Bacillus cereus} and baby corn/\textit{Shigella sonnei} for EU countries, while for non-EU countries nuts combined with either \textit{Salmonella} spp. or pathogenic \textit{E. coli} were rated as grade two priority. Level 3 priority was assigned to nuts/\textit{Salmonella} spp. for EU countries and baby corn/\textit{Shigella sonnei} and pepper/\textit{Salmonella} spp. for non-EU countries. The study provides an extensive scientific database that will be instrumental in the conceptualization of specific measures for preventing and efficiently controlling outbreaks of disease linked to FoNAO.

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KEY WORDS

Food borne outbreak, food of non animal origin (FoNAO), food/pathogen combination, biological hazard, pathogen, extensive review

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SUMMARY

Food-borne diseases caused by pathogenic bacteria, viruses and parasites are a major health concern worldwide. Although traditionally food of animal origin has been primarily implicated in outbreaks, incidences caused by contaminated food of non-animal origin (FoNAO) have been increasing, reflecting rising consumers’ demands for fresh and minimally processed fruit and vegetables. This highlights the need for an in-depth evaluation and characterization of the hazards posed by contaminated FoNAO.

The present study was set up as an extensive literature review addressing biological hazards associated with FoNAO with low water content. Search strategies were defined a priori and involved systematic searches in bibliographic databases and grey literature sources. Thereby, pathogenic bacteria, viruses and parasites that have been found associated with FoNAO with low water content were identified on a worldwide level and were further characterised regarding their prevalence and colonization behaviour. Reports on food-borne outbreaks caused by biological hazards encompassing the last ten years were compiled. Critical steps in the production and processing of the FoNAO items concerned were determined, and consumption patterns as well as trade volumes from third countries into the European Union were assessed. In total, 7710 entries (Lot1 and Lot2) from scientific databases were retrieved and 51 grey literature sources were taken into account. Following screening according to a set of relevance and quality criteria, this resulted in 315 publications used for collecting data and extracting them into an Excel-based compendium of tables.

A synopsis of the collective data set was formed for prioritising FoNAO/pathogen combinations. While the number and severity of outbreaks of disease provided the basis for a primary evaluation, qualitative criteria relating to pathogen prevalence and their colonization behaviour as well as to the production of FoNAO items were used for defining three priority groups. Level one priority worldwide was assigned to “seeds for sprouting and sprouted seeds” in combination with Salmonella spp. and to pathogenic E. coli on/in sprouts. Priority two was attributed to rice/Bacillus cereus and baby corn/Shigella sonnei for EU countries, while for non-EU countries nuts combined with either Salmonella spp. or pathogenic E.coli were rated as grade two priority. Level three priority was assigned to nuts/Salmonella spp. for EU countries and baby corn/Shigella sonnei and pepper (black/red)/Salmonella spp. for non-EU countries. The study provides a broad scientific database that will be instrumental in the conceptualization of specific measures for improving the safety of FoNAO. Ultimately, it may contribute to the prevention and a better control of food borne diseases.
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BACKGROUND AS PROVIDED BY EFSA

In May 2011 a major outbreak of STEC O104 infections occurred in Germany. More than 4,000 people were reported ill with symptoms and the outbreak resulted in the death of more than 46 people. Other countries reported a small number of people becoming ill by the same strain, most of whom had recently visited the region of northern Germany where the outbreak occurred. At the end of June, there was a second outbreak in Bordeaux, France, which was caused by the same E. coli strain. In both cases, investigations implicated sprouted seeds.

According to the 2009 European Union Summary Report on trends and sources of zoonoses, zoonotic agents and food borne outbreaks, the majority of verified outbreaks in the EU were associated with foodstuffs of animal origin. Fruit and vegetables were implicated in 43 (4.4 %) verified outbreaks. These outbreaks were primarily caused by frozen raspberries contaminated with norovirus. In addition, 8.1 % outbreaks were associated with mixed or buffet meals where foods of plant origin could not be excluded.

According to the US Centre for Disease Control and Prevention (CDC) 2008 report on surveillance for food borne disease outbreaks, the two main commodities associated with most of the outbreak-related illnesses originating from food of plant origin were fruits-nuts and vine-stalk vegetables. One of the main pathogen-commodity pair responsible for most of the outbreaks was norovirus in leafy vegetables. The pathogen-commodity pairs responsible for most of the outbreak-related illnesses were Salmonella in vine-stalk vegetables and Salmonella in fruits-nuts. In addition, in September 2011, a multistate outbreak of listeriosis linked to cantaloupe melon caused 29 deaths in the US.

These outbreaks indicate the need to consider more specific measures for food of plant origin. Thus, EFSA wants to outsource preparative work of an extensive search of scientific and technical literature for future activities related to risk posed by pathogens in food of plant origin.

Regulation (EC) No 852/2004 on the hygiene of foodstuffs lays down general hygiene requirements to be respected by food businesses at all stages of the food chain. All food business operators have to comply with requirements for good hygiene practice in accordance with this Regulation, thus preventing the contamination of food of animal and of plant origin. Establishments other than primary producers and associated activities must implement procedures based on the HACCP principles to monitor effectively the risks. In addition to the general hygiene rules, several microbiological criteria have been laid down in Regulation (EC) No 2073/2005 for food of plant origin.

The overall objectives of the present contract work are as follows: to provide an extensive literature search of available data for microbiological hazards, that may contaminate food of plant origin in the food chain (from primary production to retail), which can be used for risk assessment activities such as hazard identification, hazard characterization and exposure assessment.

An extensive literature search must be structured in a way to identify as many relevant studies as possible. The fundamental aspects of an extensive literature search are the tailored search strategy/ies (i.e. combination of search terms and Boolean operators) and the extensive list of information sources used (i.e. bibliographic databases and other sources such as e.g. journal tables of content etc.). The process of extensive literature search is clearly reported to allow transparency and reproducibility. The output of extensive literature search is an extensive collection of evidence (to be screened for relevance). An extensive literature search followed by a study selection process should be performed by the tenderer(s), to produce a set of relevant evidence, in particular to identify specific food/pathogen combinations most often linked to food borne disease originating from food of plant origin.
TERMS OF REFERENCE AS PROVIDED BY EFSA

For Lot 2, the scope of the work is:

- To carry out an extensive literature search for available data on:
  (i) production methods (farming and processing including post-harvest practices such as cutting, washing and packaging) and trade volumes from third countries to the European Union of food of plant origin with high water content such as fruits, vegetables, juices and herbs;
  (ii) consumption of all food items considered for each subcategory of food of plant origin. Literature search on consumption data shall cover, for each food subcategory, where possible, age of consumers, amounts consumed (e.g. grams/day; grams/kg body weight/day) and how the food is consumed (e.g. raw, cooked). The approach used shall be consistent, as far as possible, with the Food Classification and Description System for exposure assessment used by EFSA
  (iii) microbiological hazards (bacteria, parasites and viruses) in the food chain (from primary production to retail) that may contaminate food of plant origin with high water content such as fruits, vegetables, juices and herbs in particular:
   - hazard identification,
   - hazard characterisation,
   - prevalence and enumeration data of foodborne pathogens as part of exposure assessment;
  (iv) specific food/pathogen combinations most often linked to foodborne disease originating from food of plant origin with high water content.

- Literature searches for data regarding point (ii) shall cover all European Union Member States (including EU candidate and pre-accession countries). For points (i), (iii) and (iv) literature shall be searched at worldwide level.

- Furthermore, the literature search should include published scientific articles and academic dissertations, proceedings of conferences as well as the grey literature (national and international reports, public health institute publications, project or research reports, unpublished reports e.g. from ongoing research projects, other documents, data published on web sites and any other source relevant to the subject under assessment).

- The literature search should be conducted including multiple bibliographic databases (e.g. PubMed, CAB abstracts, Web of Science, Medline, Scopus).

- The searches should cover at least the last 10 years and should be updated, as far as possible, throughout the entire duration of the resulting contract from this tender.

- The process used for the extensive literature searches should be clearly reported to allow transparency and reproducibility. EFSA should be provided with methodologies proposed for the:
  - extensive literature search (i.e. screening criteria used in the search proposal, how many experts will screen titles, abstracts and full text; expertise of the reviewers; whether the examination of the studies will be done independently by the reviewers; how potential disagreements on study eligibility will be solved);
  - criteria used to generate the structured tables summarising the data from the selected literature and
  - identification of specific food/pathogen combinations most often linked to foodborne disease originating from food of plant origin with high water content.
  - References not considered pertinent after the screening process should be listed and reasoning should be provided why these references were not considered pertinent. References for which full text could not be retrieved on time will also be listed.
This contract was awarded by EFSA to:

Contractor: AIT Austrian Institute of Technology GmbH in consortium with AGES (Austrian Agency for Health and Food safety)

Contract title: Food of plant origin: production methods and microbiological hazards linked to food-borne disease. (Food of plant origin with low water content such as seeds, nuts, cereals, and spices)

Contract number: CFT/EFSA/BIOHAZ/2012/01 – LOT 2 - CT 2
1. Introduction

Outbreaks of gastrointestinal disease caused by the consumption of raw or minimally processed vegetables contaminated with biological hazards have increasingly been reported worldwide and within the EU. This is partly due to consumers’ increased demands for fresh produce, and especially for ready-to-eat pre-cut vegetables and fruits. For implementing future activities for mitigating risks posed by pathogens in food of non-animal origin (FoNAO) we need to pin-point the microbiological hazards linked to food-borne disease implicating FoNAO. Thus, there is a need for identifying and characterizing the bacteria, viruses and parasites that may contaminate food of plant origin together with the identification of the food items concerned. In addition, data are required that allow thorough exposure assessment, considering for instance various subcategories of food and different groups of consumers.

The present study was carried out in the frame of an assignment for a tender responding to the invitation to open tender (Ref. CH/MH/cm (2012)-out-6206701) by the EFSA Biological Hazards Unit. This study relates to Lot 2 of the tender, and thus addresses risks regarding food of non-animal origin (FoNAO) with low water content (such as seeds, nuts, cereals, and spices), while FoNAO with high water content are dealt with in a separate study relating to Lot 1 of the same tender.

Classification of the food items considered in the present study follows the categorization of FoNAO commodities set up by EFSA. FoNAO items that were allocated to Lot 2 of the tender (addressing FoNAO with low water content) and thus were included in the present study are presented in Table 1. Basically, the individual commodities categorized by EFSA were assigned to either Lot 1 or Lot 2 of the assignment according to the water content of the respective food item as it is most frequently reported. Beverages such as cocoa, coffee, herb teas, and teas were allocated to Lot 2 because low water content items such as cocoa and coffee beans or dried tea leaves were held more important regarding biological contamination of the respective commodities. Food supplements and plant extracts were also included in Lot 2 because these commodities are most often used in dehydrated state.

By performing the present study we aimed to assist in the conceptualization of future activities that are needed for securing the microbiological safety of food of plant origin. We carried out extensive literature searches to provide a comprehensive dataset of the currently available information relating to biological hazards associated with FoNAO with low water content. We employed methods of the systematic literature review, involving that a structured literature search strategy was applied that was developed a priori. Data extraction into a database was accomplished following multi-phase reviewing of the retrieved scientific and grey literature, involving relevance screening of abstracts and quality assessment of full text literature.

The objectives and specific tasks of the present study are described in chapter 2, and the methods employed for completing the project tasks are presented in chapter 3. The study results are given in chapter 4, referring to the associated structured tables shown in the appendices A to D. Conclusions resulting from the study are summarized in chapter 5.
Table 1: Classification of commodities of FoNAO with low water content as included in the present study, based on BIOHAZ classification.

| General commodity category | Specific categories | Examples of commodities |
|----------------------------|---------------------|-------------------------|
| Dry legumes, cereals, edible seeds and grains, flours and products thereof | 24. Cereals and dry legumes | Barley, buckwheat, fonio, maize (corn), millet, oats, quinoa, rye, sorghum, triticale, wheat |
| | 25. Rice | |
| | 26. Pasta | |
| | 27. Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | Bread, breakfast cereals, cornflakes flours, polenta, semolina, tortilla, various edible seeds |
| | 28. Seeds for sprouting and sprouted seeds | Alfalfa, basil cress, broccoli, borage cress, chick peas, coriander, fennel, fenugreek, garden cress, garlic, leek, lemon cress, lentil, mung bean, onion, peas, radish, shiso, sunflower, wheat |
| | 31. Nuts and nuts products | Almonds, chestnuts, coconut, hazelnuts, macadamia nut, nut bars, peanut, pistachio, walnut |
| | 32. Spices and dry powdered herbs | Chilli, cumin, curry, nutmeg, pepper (black/white) |
| | 33. Beverages* | Cocoa, coffee, herb teas, tea |
| | 37. Other processed products | Canned bottled products |
| | 39. Others | Food supplements, plant extracts |

*including composite products such as chocolate made of the basic food commodities (e.g. cocoa, coffee beans)
2. Objectives and Research Questions

Following the objectives expressed in the tender specifications, the present study aimed (i) to carry out extensive literature searches, (ii) to provide summary reports on the currently available information, and (iii) to provide EFSA with a set of relevant evidence addressing points as detailed in the tender specifications.

Specific project tasks were formulated for research areas A, B, C, and D that were indicated in the tender specifications. Tasks within research areas A, B, and C were addressed by carrying out structured literature searches that were based on specific research questions (RQs). The collective dataset obtained via the searches was then used for addressing the tasks within research area D.

Area A. Identification and characterization of biological hazards associated with food of non-animal origin (FoNAO) with low water content.

Project tasks within research area A were to identify and characterize pathogenic bacteria, viruses, and parasites associated with FoNAO with low water content. This involved exploring the prevalence of the biological hazards found in association with FoNAO with low water content and collecting data on relevant food-borne outbreaks.

Associated RQs:
- Which bacteria, viruses, and parasites, have been found associated with the food items addressed (FoNAO with low water content)?
- What is the prevalence of the hazards identified in the food commodities?
- What are the growth characteristics/requirements of the hazards identified and what is their persistence under various conditions prevailing in the food commodities?
- What is the colonization/adhesion/internalization behaviour of the hazards identified in food of non-animal origin?
- Which outbreaks have been reported or otherwise addressed concerning the individual pathogens in association with the individual food commodities (FoNAO with low water content)?

Area B. Production methods (farming and processing including post-harvest practices such as cutting, washing and packaging) of FoNAO with low water content and information on trade volumes from third countries to the European Union.

The primary task within research area B was to identify FoNAO with low water content that were associated with biological hazard contamination. Then, critical steps in the production line of these FoNAO regarding contamination with biological hazards had to be investigated. In addition, data on trade volumes of the food items from third countries to the European Union had to be provided.

Associated RQs:
- Which food items (FoNAO with low water content) have been found associated with microbiological hazards regarding contamination by pathogenic bacteria, viruses or parasites?
- Which procedures are used for the production and processing of the food items identified, including agricultural practices and post-harvest procedures?
- What are the critical steps in the production and processing procedures that are linked to risks of biological contamination?
- What are the trade volumes of the food items identified from third countries to the European Union?
Area C. Consumption of FoNAO with low water content associated with biological pathogen contamination.
The principal project task within research area C was to collect consumption data of FoNAO with low water content, including, where possible, data on the age of consumers, amounts consumed (grams/day), and how the food is consumed (e.g. raw, cooked, meals).

Associated RQs:

- What amounts of the food items identified are consumed in countries of the European Union?
- When are the food items consumed (time of day, meal)?
- Where are the food items consumed (at home or in the public)?
- Which population groups (especially age groups) consume the food items identified and in what amounts?

Area D. Food/pathogen combinations that are most often linked to food borne disease originating from FoNAO with low water content.
The major project task within area D was to form a synopsis of the data retrieved in areas A, B, and C, involving that relevant information was extracted that allowed evaluating the most important food/pathogen combinations regarding criteria such as pathogen prevalence, outbreak data, risks introduced in food production, and consumption modes.

Evaluation of food/pathogen combinations should consider the following aspects:

- What are the criteria that define the relevance of the food/pathogen combinations identified as being most critical regarding human health issues?
- Which food/pathogen combinations can be identified as most critical in EU versus non-EU countries?
- How do the hazards identified affect human health?
- What are the outbreak incidences specifically for the set of hazards identified in combination with the set of food items identified?
3. Materials and Methods

3.1. Overall research strategy

The overall research strategy followed within the present study involved that a series of literature searches were performed, addressing the research questions that were defined in correspondence with the thematic areas given in the tender specifications (see chapter 2). Thus, the literature searches were aimed at identifying and characterizing biological hazards, exploring production methods, and collecting consumption data.

The individual searches performed were inter-related and built upon each other. Within each thematic area, a set of research questions formed the basis of the specific search strategy applied. The research questions determined the key words in the bibliographic searches, and they were also used to retrieve information by scanning the grey literature sources and by using various ad-hoc strategies. Finally, the research questions set the frame for the organization of the structured tables in the appendix section (Tables 12-31) presenting the results of the searches.

Specific search strategies were developed for the thematic areas A, B, and C (see below). Each search strategy was set up as a comprehensive overall plan for the entire search process, as defined in Zins (2000). The various searches consisted each of a sequence of interrelated actions, which determined the course of the searches and thus affected the final search results. Essential steps in the search process were to ask the right questions, then to proceed with the search while inferring optional outcomes of alternative actions, to evaluate the search results, and to eventually repeat and modify the process (Zins 2000). This means, for instance, that the lists of key words related to the food commodities and microbiological hazards addressed were defined during the course of the searches and were continuously extended to address the research questions as specifically as possible.

Searches within the research areas A, B, and C were carried out in bibliographic databases by using the systematic review methodology as well as via directed searches performed in various grey literature sources. Research area D was addressed by evaluating the collective search results as described in section 3.6. Thus, a synopsis of the data retrieved via multiple searches was formed as the final outcome of the study.

3.2. Extensive literature review

The principles of the “systematic literature review” (EFSA, 2010) were applied to fulfil the project tasks formulated for research areas A, B, and C. This involved that a protocol was developed a priori that defined in advance the research question and scope and the search methods, including the eligibility criteria for the inclusion of studies into the review. Thereby, biases in the selection of research studies were reduced and reproducibility of the search strategy was granted. Figure 1 illustrates the various steps of the reviewing process, comprising literature searches and screening procedures as well as data extraction and documentation.
Figure 1: Scheme of the extensive reviewing process, including the search strategy and underlying logistical operations.
3.2.1. Searches in bibliographic databases and other literature sources

Depending on the research question, one or several bibliographic databases were used for searching scientific literature, as indicated specifically for the individual research areas (Chapter 3.3 to 3.5).

In addition, hand searching of relevant sources was performed for the various research areas concerned, including the following strategies:

- screening of websites of relevant organizations (e.g., ECDC, CDC, WHO, ProChildren Project – see individual search descriptions for details)
- checking the tables of content of relevant journals or special issues of specific journals
- obtaining “related articles” suggested during searches in PubMed/Web of Knowledge
- searching relevant literature cited in comprehensive review articles in the respective fields
- including relevant articles found during other bibliographic searches in the collection of citations used in the abstract screening (e.g., articles about outbreaks found during the search for pathogen enumeration)

Searches were performed on a worldwide level, except for consumption data, which were retrieved only from EU countries. In all searches, publications from the last ten years were considered as relevant for the present study. The cut-off date for the searches, when no more literature entries were added to the database, was set with 31 October 2012.

3.2.2. Screening abstracts for relevance

A relevance screening tool consisting of short series of questions was applied to quickly determine if an article or other literature source was relevant to answer the research question. Hence, decisions about inclusion or exclusion of articles were made according to a pre-determined method. In the first reviewing process, only the titles and abstracts of the papers or other literature entries retrieved were screened. Separate relevance screening tools were designed for the various search strategies relating to research questions in topic (A) to (D).

The relevance screening was applied to data entries collected in a Zotero 3.0.8. database (http://www.zotero.org/; Roy Rosenzweig Center for History and New Media of the George Mason University, Virginia). Corresponding to the series of questions defined in the screening tool, number codes (“tags”) were assigned to the literature entries. Subsequently, the entries were sorted according to the codes applied, allowing distinguishing relevant from non-relevant entries and collecting entries for hand-searching or further screening of the full texts.

In the screenings performed for the searches A to C, specific codes were given according to the various exclusion criteria, and a specific code was applied for inclusion regarding the research question considered. In addition, a specific code was given if inclusion or exclusion could not be decided based on the abstract, so that full text screening or discussion in the panel were necessary.

As in some cases the articles retrieved were appropriate (also) for another research question than the one actually considered, additional codes were given for collecting these references in a hand-searching pool. This was done to ensure that the information obtained was not lost, even if eventually the same reference was also retrieved via specific bibliographic searches regarding the respective research question. In particular, review articles, which often referred to more than one research question, were collected in the hand searching pools. While review articles obtained via the various searches were not used for direct data extraction, they were used to retrieve the original articles containing relevant data.
Prior to running the reviewing process, the screening tool was validated for reliability and reproducibility by having two reviewers independently apply the same selection criteria to a randomly selected set of at least twenty studies. Eventually, the selection tool was further modified in order to yield reproducible and reliable results, and was then tested again as described above.

3.2.3. Quality assessment

Full text versions of all citations identified as relevant in the first reviewing process were obtained (as far as available to the contractor) and subjected to a quality assessment step, aimed at excluding studies whose quality was too low to provide meaningful data to address the research question. A predetermined method was established for assessing the eligibility and quality of the studies collected, and only studies that were of appropriate quality were used for data extraction.

The quality assessment tools (see appendix B) were used to explore the study quality. It was checked whether the study addressed the research question (e.g., microbiological hazard), if the study outcome (e.g., hazard identification or hazard characterization) was meaningful and whether the data presentation was conclusive. Moreover, the suitability of the study design was addressed. Hence, it was checked whether the type of study was appropriate to yield meaningful information for the present extensive literature review.

As in the first reviewing process, two reviewers performed a validation step by testing the quality assessment tool on a set of randomly selected studies prior to the assessment process.

Two reviewers assessed the quality of each study in both reviewing processes, with one reviewer being primarily responsible for the screening and the other reviewer holding controlling function. Any disagreements that arose (in spite of the prior validation step) were resolved in consensus among all reviewers or (if this was not possible) were finally resolved by the project lead.

3.2.4. Data extraction

Data from all articles considered relevant in the full text quality check were extracted into multiple tables set up in Excel data sheets addressing the thematic areas A to C. The format of the Excel database was defined a priori. Basically, it was designed for assembling the research findings (results), which were then transferred to the results section in the present report document. Thus, following the eligibility screenings executed on full texts, data from a final set of literature that fulfilled all selection criteria were extracted into structured tables.

Descriptive data on the studies and on the search process were collected from the Zotero database by sorting the literature entries according to the codes (corresponding to the various inclusion and exclusion criteria) applied in the screenings. These data were filled into flow diagrams for documentation of the various searches performed.

Zotero is fully compatible with the EndNote bibliographic software system, and thus allowed that the comprehensive reference lists were finally exported into the EndNote format as requested in the tender specifications.

3.3. Search strategy used within thematic area (A) Microbiological hazards

The search strategy employed within thematic area (A) was built on the four components “hazard identification” (A1), “prevalence” (A2), “food/pathogen interaction” (A3), and “hazard characterization” (A4), corresponding to four individual searches (see below). In the process of the searches, a keyword-list of food items (FoNAO with low water content) was set up, which was used for designing the search strategies applied within the various research areas.

The searches were performed independently in three databases, i.e.
3.3.1. Development of a keyword-list of food items (FoNAO with low water content)

Based on the FoNAO list provided by EFSA (see chapter 1), a list of keywords of food items identified as relevant regarding issues of biological contamination was developed. Results from the various searches within area A (see below) were used for generating the keyword list, which was continuously extended during the following searches. The keywords compiled comprised general categories, sub-categories and a detailed list of food items, and were subsequently used in the various bibliographic and other searches throughout the project.

Table 2: List of food commodities (FoNAO with low water content) for the use as key words in bibliographic searches, where either categories, sub-categories or individual commodities (detailed list) were applied.

| Categories          | seeds OR nuts OR cereals OR spices |
|---------------------|----------------------------------|
| Sub-categories      | cereals OR dry legumes OR rice OR pasta OR seeds OR grains OR flours OR nuts OR spices OR dry powdered herbs OR vegetable oils OR products OR dried vegetables OR dried fruits OR food supplements OR plant extracts |
| Detailed list of food items | cereals OR dry legumes OR barley OR buckwheat OR fonio OR maize OR corn OR millet OR oats OR quinoa OR rye OR sorghum OR triticale OR wheat |
| OR                  | rice |
| OR                  | pasta |
Food of plant origin with low water content

3.3.2. Search regarding “hazard identification” (A1)

The aim of search A1 was to establish a comprehensive list of pathogens (bacteria, viruses, and parasites) that have been found associated with FoNAO with low water content. Bibliographic searches were performed in the PubMed and WoK bibliographic databases by using eight different search strings (Table 3). Since search A1 was performed separately for FoNAO of low water content (addressed in the present report), Table 3 gives the search results (hits) in PubMed and WoK, respectively, referring only to these commodities. In addition, the numbers of merged hits from both databases (without duplicates) are shown.

By introducing exclusion criteria via the Boolean operator “not”, search results in both WoK and PubMed were narrowed down to those food items that were of non-animal origin (see Table 3). It was verified that no hits were missed that related to food items of both animal and non-animal origin.

In addition to the use of search engines as shown below, hand searching was performed on “related articles” listed with publications retrieved via PubMed. All articles within the Internet Journal of Food Safety (http://internetjfs.org/currentissues.html) available online were screened by title.

All hits retrieved via bibliographic searches and hand searching were subjected to relevance and (if selected) to subsequent full text screening by using the respective tools presented in Figures 2 and 3.

In the relevance screening, it was checked if the publications retrieved refered to either Lot 1 or Lot 2 (or to both lots), even though the searches were performed separately for both lots. Thus, the publications could be assigned codes for either of the lots or for both lots.

Table 3: Search A1 (hazard identification) for FoNAO with low water content in two bibliographic databases.

| Search string | PubMed | Web of Knowledge | Hits (PubMed) | Hits (WOK) |
|---------------|--------|------------------|--------------|------------|
| #1 Microbiological quality OR microbial quality OR bacteriological quality [Title] AND food items** [all fields]; from 1992-2012 | Microbiological quality OR microbial quality [Title] AND food items** [Topic]; from 1992-2012 | 19 | 173 |
| #2 *** examination [Title] AND food items **[all fields]; from 1992-2012 | *** examination [Title] AND food items **[Topic]; from 1992-2012 | 1 | 5 |
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Data appropriate for insertion in results table.
- No pathogen incidence.
- No (relevant) pathogens analyzed according to list of pathogens\(^1\).
- Study type not appropriate
  (e.g., laboratory inoculation study, review\(^2\), statistical modelling study)
- Weak methodology or data presentation insufficient
  (e.g., inconsistent data, analysis of single samples)

\(^1\) This list was based on the searches “pathogen identification” and “pathogen prevalence” and includes the pathogens shown in Tables 12 to 14 in Appendix A.
\(^2\) Review articles were used to collect additional relevant articles that were not found via the bibliographic search, but they were not used for direct data extraction.

**Figure 3:** Full text screening tool for search A1 Hazard identification. *Review articles were used to collect additional relevant articles that were not found via the bibliographic search but were not used for direct data extraction.*

### 3.3.3. Search regarding “pathogen prevalence” (A2)

Search A2 was aimed at obtaining prevalence data of the pathogens identified in search A1, considering the complete list of food commodities given in Table 2. Other than in search A1, key words of FoNAO of both high and low water content were included in search A2 and all following searches. This was done to avoid redundancy in the search results, which often referred to FoNAO of both high and low water content (corresponding to Lot 1 and Lot 2 of the assignment). Search results were allocated to either Lot 1 or Lot 2 during the subsequent relevance check. Hence, Tables 4 and 5 show the numbers of hits referring to FoNAO of high and low water content, respectively. As for area A1, bibliographic searches within area A2 were carried out in the PubMed and Web of Knowledge databases. Search results from both databases were combined for each pathogen and duplicates were removed.

Depending on the pathogen concerned, some search strings contained exclusion criteria via the Boolean operator “not”. Search results were narrowed down to those relating to food items that were of non-animal origin in searches relating to *Campylobacter* sp., *Listeria* sp., *Shigella* spp. and *Salmonella* spp., which are commonly associated with animal-derived food commodities. In searches relating to *Staphylococcus aureus*, because this pathogen is often reported in a clinical context, results were excluded that referred to the respective pathogens in a clinical environment. Regarding searches involving *E. coli*, both exclusion criteria were used because of strong associations of pathogenic *E. coli* with food of animal origin and because of its high clinical relevance. It was verified that no relevant hits were missed by introducing the exclusion criteria (see Table 4, Table 5).
Table 4: Search A2/prevalence and enumeration data of pathogenic bacteria associated with FoNAO with high and low water content in two bibliographic databases.

| Search string | Pubmed Key words, Boolean operators, Settings, Time frame | Web of Knowledge Key words, Boolean operators, Settings, Time frame | Hits (PubMed) | Hits (WOK) |
|---------------|-----------------------------------------------------------|---------------------------------------------------------------|--------------|------------|
| #1            | Food items A, B [all fields] AND bacillus cereus [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND bacillus cereus [topic] AND prevalence [topic]; from 2002-2012 | 53 (A) | 104 (A) |
|               |                                                           |                                                               | 40 (B) | 89 (B)  |
| #2            | Food items A, B [all fields] AND clostridium botulinum [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND clostridium botulinum [topic] AND prevalence [topic]; from 2002-2012 | 49 (A) | 40 (A) |
|               |                                                           |                                                               | 23 (B) | 29 (B)  |
| #3            | Food items A, B [all fields] AND clostridium perfringens [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND clostridium perfringens [topic] AND prevalence [topic]; from 2002-2012 | 53 (A) | 75 (A) |
|               |                                                           |                                                               | 23 (B) | 39 (B)  |
| #4            | Food items A, B [all fields] AND aeromonas [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND aeromonas [topic] AND prevalence [topic]; from 2002-2012 | 52 (A) | 63 (A) |
|               |                                                           |                                                               | 23 (B) | 29 (B)  |
| #5            | Food items A, B [all fields] AND campylobacter [all fields] AND prevalence [all fields] NOT (a) [all fields]; from 2002-2012 | Food items A, B [topic] AND campylobacter [topic] AND prevalence [topic] NOT (a) [topic]; from 2002-2012 | 94 (A) | 82 (A) |
|               |                                                           |                                                               | 18 (B) | 36 (B)  |
| #6            | Food items A, B [all fields] AND Escherichia [all fields] AND prevalence [all fields] NOT (a),(b) [all fields]; from 2002-2012 | Food items A, B [topic] AND Escherichia [topic] AND prevalence [topic] NOT (a),(b) [topic]; from 2002-2012 | 205 (A) | 192 (A) |
|               |                                                           |                                                               | 52 (B) | 99 (B)  |
| #7            | Food items A, B [all fields] AND (Enterobacter sakazakii OR Cronobacter) [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND (Enterobacter sakazakii OR Cronobacter) [topic] AND prevalence [topic]; from 2002-2012 | 26 (A) | 33 (A) |
|               |                                                           |                                                               | 79 (B) | 30 (B)  |
| #8            | Food item A,B [all fields] AND Listeria [all fields] AND prevalence [all fields] NOT (a) [all fields]; from 1992-2012 | Food item A, B [topic] AND Listeria [topic] AND prevalence [topic] NOT (a) [topic]; from 1992-2012 | 71 (A) | 147 (A) |
|               |                                                           |                                                               | 34 (B) | 120 (B) |
| #9            | Food item A,B [all fields] AND Salmonella [all fields] AND prevalence [all fields] NOT (a) [all fields]; from 2002-2012 | Food item A, B [topic] AND Salmonella [topic] AND prevalence [topic] NOT (a) [topic]; From 2002-2012 | 315 (A) | 231 (A) |
|               |                                                           |                                                               | 347 (B) | 104 (B) |
| #10           | Food item A,B [all fields] AND Shigella [all fields] AND prevalence [all fields] NOT (a) [all fields]; from 2002-2012 | Food item A, B [topic] AND Shigella [topic] AND prevalence [topic] NOT (a) [topic]; from 2002-2012 | 57 (A) | 62 (A) |
|               |                                                           |                                                               | 38 (B) | 24 (B)  |
| #11           | Food item A,B AND Staphylococcus [all fields] AND prevalence [all fields] NOT (b) [all fields]; from 2002-2012 | Food item A, B [topic] AND staphylococcus [topic] AND prevalence [topic] NOT (b) [topic]; from 1992-2012 | 206 (A) | 152 (A) |
|               |                                                           |                                                               | 102 (B) | 114 (B) |

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Table 5: Search A2/prevalence and enumeration data of viruses and parasites associated with FoNAO with high and low water content in two bibliographic databases.

| Search String | Pubmed Key words, Boolean operators, Settings, Time frame | Web of Knowledge Key words, Boolean operators, Settings, Time frame | Hits (PubMed) | Hits (WOK) |
|---------------|----------------------------------------------------------|---------------------------------------------------------------|--------------|------------|
| #1            | Food item A, B AND vibrio [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND vibrio [topic] AND prevalence [topic]; from 2002-2012 | 140 (A) | 90 (A) |
| #13           | Food item A, B [all fields] AND yersinia [all fields] AND prevalence [all fields]; from 2002-2012 | Food items A, B [topic] AND yersinia [topic] AND prevalence [topic]; from 2002-2012 | 171 (A) | 100 (A) |

A Key words (detailed list) of FoNAO with high water content (for details see Lot 1 report)
B Key words (detailed list) of FoNAO with low water content (Lot 2)
(a) “(animal OR chicken OR egg OR poultry OR pork OR beef OR cattle OR milk OR pork OR cheese OR seafood OR mussels)”
(b) “(patient OR hospital OR resistance OR infection)"
Additional hand searching performed within search A2 included the 2009 special issue on food poisoning from raw fruit and vegetables in Epidemiology and Infection (Vol. 137, Issue 3) which was screened for relevant papers. Review articles and other articles that had been collected in the hand-searching pool (see also 3.2.2) were also screened (Duffy and Moriarty, 2003; Shields and Olson, 2003; Dawson, 2005; Crépet et al., 2007; Moore et al., 2007; Doyle and Erickson, 2008; Erickson et al., 2010; Baert et al., 2011; Bari et al., 2011b; Olaimat and Holley, 2012; Zweifel and Stephan, 2012).

All hits were subjected to relevance screening by using the tool given below (Figure 4). Articles retrieved for full-text screening were subsequently checked by using the respective tool (Figure 5).

| Question | Code | Answer |
|----------|------|--------|
| Question 1 | 10 | We do not comprehend the article language. |
| Question 2 | 20 | The article is not about a FoNAO. |
| Question 3 | 30 | The article is about the prevalence of the searched pathogen on a FoNAO with high water content (Lot1). |
| | 31 | The article contains other information concerning the pathogen. |
| | 32 | The article contains data about other pathogenic microorganism associated with food items of Lot1. |
| | 33 | The article contains information about outbreak data associated with food items of Lot1. |
| Question 4 | 40 | The article is about the prevalence of the searched pathogen on a FoNAO with low water content (Lot2). |
| | 41 | The article contains other information concerning the pathogen. |
| | 42 | The article contains data about other pathogenic microorganism associated with food items of Lot2. |
| | 43 | The article contains information about outbreak data associated with food items of Lot2. |
| Question 5 | 50 | The inclusion will be further discussed. |
| Question 6 | 60 | The full text has to be checked for clarification. |

Figure 4: Relevance screening tool for search A2 Prevalence and enumeration data.

- Data appropriate for insertion in results table.
- No pathogen incidence.
- No (relevant) pathogens analysed according to list of pathogens\(^1\).
- Study type not appropriate (e.g., laboratory inoculation study, review\(^*\), statistical modelling study)
- Weak methodology or data presentation insufficient (e.g., inconsistent data, analysis of single samples)

\(^1\)This list was based on the searches “pathogen identification” and “pathogen prevalence” and includes the pathogens shown in Tables 12 to 14 in Appendix A.

Figure 5: Full text screening tool for search A2 Prevalence and enumeration data. *Review articles were used to collect additional relevant articles that were not found via the bibliographic search but were not used for direct data extraction.

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3.3.4. Search regarding “food/pathogen interaction” (A3)

Search A3 was aimed at collecting data on the persistence and colonization behaviour of the pathogens in the food commodities given above. Thus, besides exploring the growth characteristics/requirements of the hazards identified, the colonization/adhesion/internalization behaviour in FoNAO with low water content and relevant mitigation options were addressed. Bibliographic searches were carried out in the WoK and CAB Abstracts databases.

Table 6 presents the strategy used in search A3 interaction of bacteria, viruses and parasites associated with FoNAO. The searches were performed for both FoNAO of high and low water content. In the subsequent relevance screening, articles were assigned to either Lot 1 or Lot 2 according to the water content of the food items addressed. Results from both bibliographic databases were combined and duplicates removed.

Table 6: Search A3 interaction of pathogenic bacteria, viruses and parasites associated with FoNAO with high and low water content in two bibliographic databases.

| Pathogen | Search strategy | Hits (WoK) | Hits (CAB Abstracts) |
|----------|----------------|------------|---------------------|
| Bacteria | A) and B) [title] AND Bacillus cereus or Clostridium botulinum or Clostridium perfringens or Aeromonas or Campylobacter or Escherichia coli O157:H7 or Shiga-toxin producing E. coli or STEC or Enterogaegregative E. coli or EAEC or enterotoxigenic E. coli or ETIE or Enterobacter sakazakii or Cronobacter or Listeria or Salmonella [title] AND growth or growth profile or dynamics or growth potential or bacterial counts or bacterial count or viability or viable or survival or proliferation or bacterial load or presence or occurrence or incidence or enumeration or persistence or pathogen number or colonization or adhesion or internalization or invasion or attachment or infestation or plant host or non-animal or infection or plant colonization or plant colonization [title] Years 2002-2012 (current) | 864 | 441 |
| Viruses  | A) and B) [title] AND Calicivirus or Norovirus or Norwalk or Norwalk-like Virus or Sapovirus or Aichi virus or Astrovirus or Coronavirus or Enteric adenovirus or Rotavirus or Hepatitis A or Hepatitis E [title] AND growth or growth profile or dynamics or growth potential or bacterial counts or bacterial count or viability or viable or survival or proliferation or bacterial load or presence or occurrence or incidence or enumeration or persistence or pathogen number or colonization or adhesion or internalization or invasion or attachment or infestation or plant host or non-animal or infection or plant colonization or plant colonization [title] Years 2002-2012 (current) | 44 | 11 |
| Parasites| A) and B) [title] AND Protozoan parasite OR Cyclospora OR Cryptosporidium OR Giardia OR Isospora OR Helminth parasite OR parasitic worm OR Ancylostoma or Necator americanus OR hookworm OR Ascaris OR Hymenolepis OR Strongyloides stercoralis OR Taenia OR Trichnella OR Trichuris [title] AND growth or growth profile or dynamics or growth potential or bacterial counts or bacterial count or viability or viable or survival or proliferation or bacterial load or presence or occurrence or incidence or enumeration or persistence or pathogen number or colonization or adhesion or internalization or invasion or attachment or infestation or plant host or non-animal or infection or plant colonization or plant colonization [title] Years 2002-2012 (current) | 23 | 12 |

A Key words of FoNAO (detailed list) with high water content (Lot 1)
B Key words of FoNAO (detailed list) with low water content (Lot 2)
All hits were subjected to relevance screening by using the tool given below (Figure 6). Articles retrieved for full-text screening were subsequently checked by using the respective tool (Figure 7).

| Question | Code | Answer |
|----------|------|--------|
| Question 1 | 10 | We do not comprehend the article language. |
| Question 2 | 20 | The main subject of the article is not about a FoNAO from Lot1 or Lot2. |
| Question 3 | 30 | The article is not about a pathogen. |
| Question 4 | 40 | The article is about survival, growth or persistence on a FoNAO of Lot1. |
| Question 5 | 50 | The article is about survival, growth or persistence on a FoNAO of Lot2. |
| Question 6 | 60 | Inclusion of the article will be discussed in the panel. |
| Question 7 | 70 | The full text is required to find out about the contents. |

**Figure 6:** Relevance screening tool for search A3 food/pathogen interaction.

- Data inserted in table
- Study type not appropriate (e.g. laboratory inoculation study, review*, statistical modelling study)
- Weak methodology or data presentation

**Figure 7:** Full text screening tool for search A3 food/pathogen interaction.*Review articles were used to collect additional relevant articles that were not found via the bibliographic search but were not used for direct data extraction.
3.3.5. Search regarding “hazard characterization” (A4)

The aim of search A4 was to collect data on food-borne outbreaks that could be traced back to the consumption of FoNAO with low water content.

Besides performing bibliographic searches (Table 7) using two different search engines (WoK, PubMed), information was collected from grey literature, including data from US multistate outbreaks of the Center of Disease Control (CDC) USA (2006-2012) and from the European Centre for Disease Prevention and Control (ECDC) reports (2009, 2010). Searches were performed simultaneously for FoNAO with low and high water content. During the relevance screening, articles were allocated to Lot1 or Lot2 depending on the water content of the food items addressed.

Table 7: Search A4/Outbreaks caused by food borne pathogens related to FoNAO with high and low water content in two bibliographic databases.

| Search string | Pubmed | Web of Knowledge | Hits (PubMed) | Hits (WOK) |
|---------------|--------|------------------|---------------|------------|
| # 1           | Outbreak [Title] OR food-borne outbreak [Title/Abstract] OR foodborne outbreak [Title/Abstract] AND A) B) [Title]; from 2002-2012 | Outbreak [title] OR food-borne outbreak [topic] OR foodborne outbreak [topic] | 778 (A) | 308 (A) |
|               |        |                  |               | 283 (B) | 63 (B) |
|               |        |                  | (total 823)   | (total 336) |
| A             | Key words of FoNAO (detailed list) with high water content (Lot 1) | | | |
| B             | Key words of FoNAO (detailed list) with low water content (Lot 2) | | | |

Furthermore, review articles were screened for additional references describing food-borne outbreaks related to FoNAO (Tribst et al., 2009; Olaimat and Holley, 2012; Pexara et al., 2012; Zweifel and Stephan, 2012).

The relevance and full text screening tools applied within search A4 are presented in Figures 8 and 9.
Food of plant origin with low water content

| Question | Description | Answer |
|----------|-------------|--------|
| 7        | Should the inclusion of the article be discussed in the panel? | 60 | The inclusion will be further discussed in the panel. |
| 8        | Should the full text be checked for details? | 70 | The full text has to be checked for clarification. |
| 9        | Is the article a review article in which outbreak data might be found? | 80 | The article is a review and outbreak data might be extracted in a hand searching approach. |

**Figure 8:** Relevance screening tool for search A4 Hazard characterization (outbreaks).

- Data appropriate for insertion in table
- Outbreak before 2002
- Not about a FoNAO
- Study type not appropriate (e.g. review*, statistical modelling, laboratory study, results revised**)
- Weak methodology or data presentation insufficient (e.g., inconsistent or missing data)
- Outbreak already documented (article added as further reference)
- Food source or pathogen not unambiguously identified

*Review articles were used to collect additional relevant articles that were not found via the bibliographic search, but were not used for direct data extraction.
**Outbreak initially traced back to a wrong source - later articles revise these findings.

**Figure 9:** Full text screening tool for search A4 Hazard characterization (outbreaks).

3.4. **Search strategy used within thematic area (B) Production**

The aim of the search performed within thematic area (B) was to identify critical points in the primary production and the processing of the food items that have been found associated with biological hazards. Production processes for the same food item can vary considerably between, and sometimes even within countries (FAO/WHO, 2011, online). Therefore, the search was focused on the identification of critical points and contamination sources during primary production and processing rather than on a description of complete production processes.

“Critical points” have to be distinguished from “Critical Control Points (CCPs)” as determined by the “Hazard Analysis Critical Control Point (HACCP)” system. The term “critical point” as used in the present report describes a production step which was identified as possible entry point for biological contamination. The critical points in the production processes for food items belonging to the same FoNAO category were assumed to be comparable.

The focus of the search was set on obtaining GAP/GMP/HACCP documents and guidelines (comprising grey literature) available on the internet that address the mitigation of risks within the production process. By using this search strategy, mainly documents were collected that are meant for the use by producers and thus are of practical relevance.

A systematic web-based search was carried out via the google search engine (http://www.google.com/), using keywords derived from the outcome of the searches within thematic area (A).

Keywords relating to food items, processing stages and biological hazards were extracted from the search results of area A (listed in tables 9 to 11), and were then applied in combination with...
Production-relevant terms (i.e. production, cultivation, harvesting, and different terms concerning quality control and management such as HACCP, control, GAP, GMP, quality control, and contamination).

The following search strings were used:

[(Food item)* AND Production]
OR [(Food item)* AND Cultivation AND Harvesting]
OR [(Food item)* AND Production AND (Processing stage)**]
OR [(Food item)* AND Production AND Pathogen]
OR [(Food item)* AND Production AND (Processing stage)** AND (Pathogen)***]
OR [(Food item)* AND Production AND HACCP]
OR [(Food item)* AND Production AND (Processing stage)** AND HACCP]
OR [(Food item)* AND Production AND Control]
OR [(Food item)* AND Production AND (Processing stage)** AND Control]
OR [(Food item)* AND Production AND GAP]
OR [(Food item)* AND Production AND Processing stage** AND GMP]
OR [(Food item)* AND Production AND Quality control]
OR [(Food item)* AND Production AND (Processing stage)** AND Quality control]
OR [(Food item)* AND Production AND Contamination]
OR [(Food item)* AND Production AND (Pathogen)*** AND Contamination]
OR [(Food item)* AND Production AND (Processing stage)** AND Contamination]
OR [(Food item)* AND Production AND (Processing stage)** AND (Pathogen)*** AND Contamination]

* Keyword list (FoNAO with low water content; Table 1)
** specific processing stage as found associated with the respective food item, see Table 20, 21
*** specific pathogen(s) as found associated with the respective food item, see Table 20, 21

The relevance of the documents (hits) was assessed by screening titles and summaries/short descriptions of the search results. Documents which were expected to contain relevant information were downloaded, and the full texts were screened for information concerning critical control points in the primary production and processing of the food items under investigation.

To identify relevant information contained in complex documents, text searches were done by using truncated terms like contamin* and microbi* as well as relevant biological hazards according to the list presented in Table 9.

Complementary, scientific literature searches was done in the PubMed and CAB abstracts databases by using the search strings given above, which resulted in only a few articles. The PubMed database allowed accessing citations and abstracts for biomedical literature. CAB was selected as a complementary database because it covers the applied life sciences, and was thus expected to provide information that is of practical relevance concerning the production of FoNAO commodities. Scientific articles were also obtained during the searches using the google search engine (http://www.google.com).

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3.5. Search strategy used within thematic area (C) Consumption

The aim of the search was to collect data related to the consumption of FoNAO associated with microbiological pathogens as identified in research area A. The most detailed compilation of consumption data of FoNAO is given in the Comprehensive European Food Consumption Database by EFSA (http://www.efsa.europa.eu/en/date-foodcdb/date-fooddb.htm), which at the request of EFSA was not considered in the present study (since this database can be consulted internally). Instead, specific information on consumption habits and the dietary intake of FoNAO by specific population groups (e.g. elderly, children, toddlers, pregnant women) was retrieved from scientific publications.

Thus, bibliographic searches were performed in WoK, SciVerse Scopus and CAB abstracts, aimed at retrieving information from multiple and varied sources involving various search algorithms. In addition to the comprehensive WoK and CAB Abstract databases, Scopus was selected as the largest abstract and citation database of peer-reviewed literature.

Corresponding search strings were used for the three databases (Tables 8 and 9). In all cases, the exclusion criterion “cancer” was introduced to exclude studies focusing on anti-cancerogenic effects of vegetable-derived compounds such as polyphenols, which did not deliver any quantitative consumption data of FoNAO.

Table 8: Search C1/Consumption habits (frequency, place) regarding FoNAO.

| Search Database       | Search Strategy                                                                                                                                   | Results |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| Scopus* (keywords,   | Categories A, B [title, abstract and keywords] AND consumption OR frequency OR time OR routine OR daily OR monthly OR meal OR breakfast OR lunch OR tea OR dinner OR supper OR snack OR home-made OR restaurant OR canteen OR coffee shop OR cafeteria OR school OR kindergarten OR nursery [title, abstract and keywords] AND Europe [title, abstract and keywords] NOT cancer [title, abstract and keywords]; time-frame 2002-2012 | 121     |
| Boolean operators,   |                                                                                                                                                  |         |
| settings              |                                                                                                                                                  |         |
| WOK (keywords,       | Subcategories A, B [title] AND consumption OR frequency OR time OR routine OR daily OR monthly OR meal OR breakfast OR lunch OR tea OR dinner OR supper OR snack OR home-made OR restaurant OR canteen OR coffee shop OR cafeteria OR school OR kindergarten OR nursery [title] AND Europe or European [title] NOT cancer [topic]; time-frame 2002-2012 | 34      |
| Boolean operators,   |                                                                                                                                                  |         |
| settings              |                                                                                                                                                  |         |
| CAB Abstracts (keywords, Boolean operators, settings) | Subcategories A, B [title] AND consumption OR frequency OR time OR routine OR daily OR monthly OR meal OR breakfast OR lunch OR tea OR dinner OR supper OR snack OR home-made OR restaurant OR canteen OR coffee shop OR cafeteria OR school OR kindergarten OR nursery [title] AND Europe or European [title] NOT cancer [all fields]; time-frame 2002-2012 | 10      |

*Note that only the food categories list, (i.e. fruits, vegetables, produce, juices, herbs) could be used in this search due to the limited amount of search words that can be entered in Scopus.

A Key words of FoNAO with high water content (Lot 1)
B Key words of FoNAO with low water content (Lot 2)
Table 9: Search C2/Consumption of FoNAO by various population groups

| Search Database | Search Strategy | Results |
|-----------------|-----------------|---------|
| Scopus* (keywords, Boolean operators, settings) | Categories A, B [title] age OR baby OR toddler OR children OR infant OR adolescent OR teenager OR junior OR juvenile OR adult OR grown-up OR elderly OR very elderly OR senior OR aged OR young OR old OR man OR woman OR patient OR patients OR health* OR pregnant OR breastfeeding OR boys OR girls OR mother OR maternal [title] AND Europe OR European [title, abstract and keywords] AND NOT cancer [title, abstract and keywords]; time-frame 2002-2012 | 12 |
| WOK (keywords, Boolean operators, settings) | Subcategories A, B [title] AND age OR baby OR toddler OR child OR children OR infant OR adolescent OR teenager OR juvenile OR junior OR adult OR grown-up OR elderly OR very elderly OR senior OR aged OR young OR old OR man OR woman OR women OR patient OR patients OR health* OR pregnant OR “breast feeding” OR breastfeeding OR boys OR girls OR mother OR maternal [title] AND Europe OR European [title] NOT cancer [topic]; time-frame 2002-2012 | 67 |
| CAB Abstracts (keywords, Boolean operators, settings) | Subcategories A, B [title] AND age OR baby OR toddler OR children OR infant OR adolescent OR teenager OR juvenile OR junior OR adult OR grown-up OR very elderly OR senior OR young OR old OR man OR woman OR women OR patient OR patients OR health* OR pregnant OR breastfeeding OR boys OR girls OR mother OR maternal [title] AND Europe OR European [title] NOT cancer [all fields]; time-frame 2002-2012 | 12 |

*Note that only the food categories list, (i.e. fruits, vegetables, produce, juices, herbs) could be used in this search due to the limited amount of search words that can be entered in Scopus.
A Key words of FoNAO with high water content (Lot 1)
B Key words of FoNAO with low water content (Lot 2)

Search results from both searches (C1 and C2) using the three databases were combined to avoid redundancy, and were subjected to relevance and full text screening by using the tools presented below (Figures 10 and 11).

| Question | Answer code | Answer |
|----------|-------------|--------|
| Question 1 | Do we comprehend the article language? | 10 | We do not comprehend the article language. |
| Question 2 | Is the article about food consumption patterns in a European Country? | 20 | The article is not about food consumption patterns in a European Country. |
| Question 3 | Does the article contain quantitative data (food frequency, amounts) about food consumption? | 30 | The article describes quantitative data about food consumption. |
| Question 4 | Is the article about toddlers, children, adolescents? | 40 | The article is about toddlers, children or adolescents. |
| Question 5 | Is the article about adults? | 60 | The article is about adults. |
| Question 6 | Is the article about elderly people? | 70 | The article is about elderly persons. |
| Question 7 | Is the article about food consumption patterns, but does not describe quantitative data? | 80 | The article might contain relevant data, but not quantitative ones. |
| Question 8 | Should the inclusion of the article be discussed in the panel? | 100 | The inclusion will be further discussed in the panel. |

Figure 10: Relevance screening tool for search C1 Consumption.
Data appropriate for insertion in table
No European study or study type inappropriate
Data format inappropriate

Figure 11: Full text screening tool for search C1 Consumption.

3.6. Methodology for ranking FoNAO/pathogen combinations (thematic area D)

3.6.1. Method development

The methodology applied for identifying FoNAO/pathogen combinations that were considered as most important regarding risks to human health involved that a synopsis of the results from the individual searches in research areas A to C was formed. Thus, the collective data retrieved in searches A to C were used to evaluate the FoNAO/pathogen combinations regarding multiple qualitative and quantitative criteria as described in sections 3.6.2 and 3.6.3.

Following data extraction into structured tables, it became evident that outbreak incidences reported for the various FoNAO/pathogen combinations presented the primary basis for evaluation. Reports on outbreaks yielded the most comprehensive data set assembled within the present study, and allowed a clear and unambiguous association of biological hazards with FoNAO commodities. Furthermore, numbers of cases reported together with information regarding the severity of outbreaks (i.e. number of hospitalisations and number of deaths) allowed that a quantitative analysis of the outbreak data was performed.

By contrast, the data on pathogen prevalence obtained via search A2 depended very much on parameters such as type of study performed, type and extent of survey, number of samples analyzed, methodology used, etc. Similarly, information on food/pathogen interaction in the food commodities considered and on mitigation strategies (search A3) was fragmented and biased for methodology and study design. This was because studies on pathogen food/pathogen interaction and hazard mitigation as reported in the retrieved publications had not been performed in the same way (using the same methodology) for the various pathogens considered in the present report, and data were partly not available or not comparable. While numbers of publications on pathogen prevalence and outbreaks also gave a comprehensive data set, they were not considered as equally appropriate criteria because they also contained study-related biases. Data relating to production and consumption issues (searches B and C) were not equally comprehensive for the various food items considered. Hence, outbreak incidences represented the basis for a primary evaluation step, and the collective data on pathogen prevalence, food/pathogen interaction, and production were used in a qualitative way for evaluating the FoNAO/pathogen combinations.

3.6.2. Evaluation based on outbreak data

Outbreak information was used in a quantitative manner for the primary evaluation of FoNAO/pathogen combinations.

Specifically, FoNAO/pathogen combinations were identified that were associated with outbreaks involving the ten highest numbers of cases, the ten highest numbers of hospitalisations, and involving cases of death. This selection process was performed separately for bacteria-, virus- and parasite-related outbreaks, and distinct rankings were carried out for outbreak cases reported for EU and non-EU countries.
In this primary evaluation procedure, those FoNAO/pathogen combinations that were involved in outbreaks that could not be allocated to a single specific FoNAO commodity and that included composite FoNAO commodities (that were composed of multiple food items) were excluded. This was done because we aimed to identify FoNAO/pathogen combinations implicating specific, individual food items that are considered most critical regarding contamination with pathogenic bacteria, viruses or parasites.

The primary evaluation procedure resulted in two comprehensive sets of FoNAO/pathogen combinations for EU and non EU countries, respectively, which formed the basis for the second evaluation step. Results of the ranking of FoNAO/pathogen combinations involved in outbreaks according to the number of cases, the number of hospitalisations, and the number of deaths are presented in the results section (with the associated tables 30 to 35 being presented in appendix D).

3.6.3. Evaluation based on multiple qualitative criteria

In the scope of the second evaluation step, the complex information collected via searches A to C was used in a qualitative way to evaluate the FoNAO/pathogen combinations selected in the primary ranking procedure.

Specifically, information obtained via the searches in areas A to C was used to define criteria that allowed a grading of the FoNAO/pathogen combinations within the four aspects “outbreaks”, “production”, “prevalence”, and “food/pathogen interaction”. Additionally, the relative infectivity of the relevant pathogens was evaluated based on information provided in Kothary and Babu (2001) and Koopmans and Duizer (2004) and by screening relevant fact sheets by the CDC. This information was used for characterising food/pathogen interaction (see below).

The following procedure was applied for the prioritisation of FoNAO/pathogen combinations, considering the four criteria “outbreaks”, “production”, “prevalence”, and “food/pathogen interaction” (see also Fig. 12):

**Outbreaks.** As the most important criterion for prioritisation, FoNAO/pathogen combinations were graded in relation to outbreaks with “A” (“highly critical”) if (i) cases were high (among the top 10 rankings), (ii) hospitalisations were high (among the top 10 rankings) and/or cases of death were involved, and if (iii) multiple outbreaks involving the given combination had been reported. “B” grading (“critical”) was applied if two of the three above criteria (i) to (iii) were fulfilled, and “C” grading (“moderate critical”) was applied if one of the three criteria (i) to (iii) was fulfilled.

**Production.** A given FoNAO/pathogen combination was graded “A” if multiple critical factors in the production and/or processing were identified as important regarding biological contamination. “B” grading was applied if a single factor was identified as critical for the given FoNAO/pathogen combination. This was done because control measures supposedly are more easily introduced and followed when focusing on a single factor as compared to multiple factors.

**Prevalence.** If prevalence data for the given FoNAO/pathogen combination had been retrieved via search A2, an additional grade “A” was applied regarding the prevalence criterion.

**Food/pathogen interaction.** If a critical interaction (namely attachment, biofilm formation, or internalisation) had been evidenced for the pathogen in a given FoNAO/pathogen combination, an additional grade “A” was applied regarding this criterion. Similarly, high infectivity of the pathogen (meaning a low infectious dose) resulted in “A” grading, based on the evaluation by Kothary and Babu (2001) and according to Koopmans and Duizer (2004) as well as specific CDC fact sheets.
The following **classification scheme** was applied for the prioritisation of FoNAO/pathogen combinations (see also Fig. 12):

**Level 1 Priority** was given to combinations yielding at least triple A grading, with A grading in outbreaks being a precondition.

**Level 2 Priority** was given to combinations yielding double A grading, with A or B grading in outbreaks being a precondition.

**Level 3 Priority** was given to combinations that had at least one A grade in either of the four criteria together with some other distinctive feature (i.e. any other grading in another aspect). Hence, FoNAO/pathogen combinations that were not assigned any A grade or were assigned only one A grade without any other grade regarding some other aspect were excluded from the priority list.

The prioritisation method applied combined a quantitative ranking procedure (i.e. ranking of FoNAO/pathogen combinations according to quantitative outbreak data) with a qualitative approach (i.e. the evaluation of FoNAO/pathogen combinations regarding the criteria “outbreaks”, “production”, “prevalence”, and “food/pathogen interaction”). This strategy allowed evaluating FoNAO/pathogen combinations regarding multiple aspects that were explored in the study areas A to C. Since the specific data used for the prioritisation were heterogeneous and inconsistent for the various combinations, criteria were defined that were applicable to all combinations. By using the classification scheme described above, FoNAO/pathogen combinations were allocated to priority groups.

The specific criteria used to assign the various FoNAO/pathogen combinations to priority groups are shown below. This methodology was applied separately for EU and non-EU countries, respectively.

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**Figure 12:** Scheme applied for the prioritisation of FoNAO/pathogen combinations. A, B and C grading corresponds to factors that are “highly critical”, “critical” and “moderately critical” regarding food safety, respectively, within each of the four criteria “outbreaks”, “production”, “prevalence” and “food/pathogen interaction”. For further details see text.
4. Results

4.1. Microbiological hazards that may contaminate FoNAO with low water content

Data concerning research area A were retrieved via four individual searches, and consequently were extracted into tables presenting data on hazard identification (A1), hazard prevalence (A2), food/pathogen interaction (A3), and hazard characterisation (A4).

In the following sections, the study selection procedures underlying the various searches are described and the information contained in the tables is summarized. The associated tables are shown in the appendix A.

4.1.1. Hazard identification (A1)

In search A1, separate bibliographic searches using scientific databases were carried out especially for FoNAO with high and low water content, respectively, relating to Lot 1 and Lot 2 of the assignment. However, literature entries obtained for Lot 1 and Lot 2 were combined for performing the relevance check, because many publications dealt with a combination of food items of both high and low water content.

As depicted in Figure 13, in total 702 abstracts collected via bibliographic searches were subjected to the relevance screening, 171 of which were screened in full text in the following quality check. 23 publications retrieved via hand-searching were added to the quality screening. Finally, 52 publications relating to Lot 1 and 27 publications relating to Lot 2 met the quality criteria and were selected for data extraction. Thus, for the present study only data relating to FoNAO with low water content were extracted into the tables shown in appendix A.

Tables 12 to 14 in appendix A show the various bacterial pathogens, viruses, and parasites that have been identified as being associated with items of FoNAO with low water content, listed in alphabetical order. The food/pathogen combinations presented were initially derived from the results of search A1, but were then extended with data from the following, more specific searches (mainly A2). Search A1 was carried out on a worldwide scale, and data are given collectively for EU and non-EU countries. Besides FoNAO categories, the food item(s) concerned and the sources of the food, also the countries are given where the food commodities were found in association with a biological contaminant (e.g. site of survey or location of the outbreak, not necessarily the place of origin/production of the food commodity analysed). Thus, the tables give an overview of the biological hazards as they have been described in association with multiple FoNAO items with low water content that are included in the various FoNAO categories (see Table 1) considered in the present study.

Bacterial pathogens found associated with FoNAO with low water content comprise representatives of the genera Bacillus, Campylobacter, Cronobacter, Enterobacter, Salmonella, Shigella as well as Klebsiella pneumoniae, Listeria monocytogenes Pseudomonas aeruginosa, Staphylococcus aureus and Yersinia enterocolitica. Of in total 103 associations of biological hazards with FoNAO with low water content identified in the literature, most of them were with Cronobacter spp. (29 combinations reported) and Salmonella spp. (24 combinations reported), Cronobacter spp. included C. dublinensis, C. malonaticus, C. muyjensis, and C. sakazakii, and Salmonella spp. comprised multiple serovars (i.e. Agona, Bredeney, Enteritidis, Infantis, Kentucky, Muenchen, Newport, Typhi, Typhimurium, and unspecified serovars).

Notably, no viruses have been described on/in FoNAO with low water content. Parasites that have been described in association with FoNAO with low water content include Cryptosporidium spp, Enterocytozoon bieneusi, Giardia spp., and Microsporidia spores.
The list of pathogens established via search A1 was used in subsequent keyword searches concerning specific research questions in areas B and C.

Figure 13: Flow chart of the study selection process underlying search A1. * The respective articles were then assigned to categories for inclusion or exclusion.
4.1.2. Hazard prevalence and enumeration data (A2)

Bibliographic searches regarding the prevalence of bacterial pathogens, viruses and parasites on/in items of FoNAO were performed in the WoK and PubMed databases by using 20 search strings each for the set of bacteria, viruses, and parasites that have been identified via search A1. Searches were done for the collective food items relating to Lot 1 and Lot 2 of the assignment, resulting in 4751 potentially relevant abstracts that were subjected to the relevance check. The vast majority of 4283 abstracts were excluded because they did not deal with FoNAO or because of language restrictions, and only 146 articles were identified as relevant for Lot 2 (since they related to FoNAO with low water content). However, in total 670 articles were found to potentially contain information that may be of relevance not only for research area A2 but also for other areas, and were hence added to the respective hand searching pools for further evaluation. Together with 12 articles retrieved via hand searching, in total 438 full text articles were accessed and checked in the quality check. Of those, 55 articles were finally selected for extracting prevalence data in Lot 2 (Figure 14).

Tables 13 and 14 in appendix A present the data extracted from scientific articles retrieved via search A2. Additionally, data collected via search A1 were included, which had been deposited in the hand searching pool (because they reported on detection rates, see Figure 14). The tables show prevalence data (detection rates) for pathogenic bacteria, viruses, and parasites that were reported in association with FoNAO with low water content. While table 13 gives the information for EU countries, data from non-EU countries are shown in Table 14.

The scope of Tables 13 and 14 is to demonstrate the association of various pathogenic bacteria, viruses and parasites with specific food items found in scientific publications. Furthermore, the tables illustrate what are the specific prevalences (detection rates) of the biological hazards, considering sources and processing states of the food items. The pathogens are listed in alphabetical order, and additional information is given on the various FoNAO categories concerned and on the country where the studies or surveys were performed. Like the data on hazard identification shown in Table 12, no detection rates have been reported for viruses on/in FoNAO with low water content.

Detection rates of biological hazards varied considerably, ranging from 0.01 to 100%. This reflects the various methodologies applied in the studies and surveys, and that the sample numbers investigated were in a broad range. Thus, while the information on detection rates of biological hazards on/in FoNAO provides a detailed database on surveys and studies performed in EU and non-EU countries, the detection rates are not suited for comparison regarding the relative importance of the FoNAO item/pathogen combinations. Still, studies reporting on detection rates give an indication that the FoNAO/pathogen combination concerned may potentially represent a food safety problem.
Figure 14: Flow chart of the study selection process underlying search A2. * The respective articles were then assigned to categories for inclusion or exclusion.
4.1.3. Food/pathogen interaction (A3)

Bibliographic searches regarding the interaction of bacterial pathogens, viruses and parasites with items of FoNAO were done in the WoK and PubMed databases, yielding 953 potentially relevant abstracts. The searches were done for the collective food items relating to Lot 1 and Lot 2 of the assignment, however, search results were assigned to either Lot 1 (217 relevant publications) or Lot 2 (55 relevant publications) during the relevance screening. Following quality checking of the full text publications, 48 articles were used for data extraction in Lot 1. Of those, 30 articles gave data on the growth characteristics of biological pathogens, 8 gave data on the colonisation behaviour of pathogenic bacteria on/in FoNAO items, and 10 contained information on the mitigation of pathogen contamination (Figure 15).

Table 15 in appendix A presents the results of search A3, comprising data relating to the growth characteristics of pathogenic bacteria and persistence of viruses on/in items of FoNAO under various experimental conditions (e.g. temperature, pH, various amendments) and exposure times. In cases where multiple treatments were addressed, only the most effective conditions within a specific study were extracted. Since data were mostly derived from inoculation studies, in most cases the initial inoculation dose is given together with the increase or decrease in colony forming units (cfu) numbers.

Table 16 in appendix A contains data on the colonisation behaviour of pathogenic bacteria associated with FoNAO with low water content. Information was collected from studies that related to the attachment, biofilm formation and/or the internalisation of the bacteria. Specific information on colonisation is shown in the “details” column. For instance, attachment and/or biofilm formation on FoNAO with low water content have been described for pathogenic *E.coli*, *Listeria* spp, and *Salmonella* spp. In addition, internalisation into FoNAO with low water content has been reported for *Bacillus cereus*, *E. coli*, several *Salmonella* serovars, and *Listeria monocytogenes*. This implicates a critical behaviour of the pathogens regarding food safety, which has to be considered when evaluating their importance regarding food safety issues.

Treatments applied for the mitigation of biological contamination are shown in Table 17 in appendix A. For the various pathogenic bacteria, viruses, and parasites the associated food commodities are given where treatments have been applied for reducing pathogen loads. In most studies either chemical or physical treatments were applied, and hence, the specific conditions are detailed (including concentrations of additives, treatment time, inoculation details) together with the reduction effects of the treatment on the pathogens.
Figure 15: Flow chart of the study selection process underlying search A3. * The respective articles were then assigned to categories for inclusion or exclusion.
4.1.4. Hazard characterization (A4)

The WoK and CAB bibliographic databases were searched for data on outbreaks of disease that could be traced back to bacterial pathogens, viruses, and parasites linked to FoNAO with low water content. Of 1091 potentially relevant abstracts identified via the searches, 141 and 46 were considered as relevant for providing information on outbreak data relating to Lot 1 and Lot 2 of the assignment, respectively. In addition to scientific literature entries identified via the bibliographic searches, hand searching of various scientific and grey literature sources (e.g. CDC and ECDC reports) yielded 42 documents that were screened for relevance. Following quality checking of the full text publications, 43 articles were used for data extraction in Lot 2 (Figure 16).

Tables 18 and 19 in appendix A present the outbreak data obtained via search A4 for EU countries (including mixed outbreaks concerning EU and non-EU countries) and non EU countries, respectively. For EU countries, data are given for pathogenic bacteria and viruses that have been reported in the publications as being associated with FoNAO with low water content. However, for non-EU countries only reports on bacterial pathogen-associated outbreaks have been retrieved. The individual outbreaks are listed only once with references of all documents relating to it, comprising scientific and grey literature sources.

For both EU and non EU countries, various serovars of Salmonella were most often implicated in outbreaks, accounting for 34 of in total 64 outbreaks (EU) and 13 out of in total 18 outbreaks (non-EU). Other bacteria involved in outbreaks comprise Bacillus cereus, Clostridium botulinum, Clostridium perfringens, pathogenic E.coli, Shigella sonnei, Staphylococcus aureus, and Yersinia enterocolitica. Among the viruses, Norovirus and Hepatitis A virus were reportedly associated with outbreaks in EU countries. Parasites have not been found involved in FoNAO (low water content)-related outbreaks.

Besides FoNAO categories and food items linked to the outbreaks, in Tables 18 and 19 comments are given on food sources and processing states of the implicated FoNAO items if available, together with the countries where the outbreaks occurred. The tables contain information on the year of the outbreak, on the number of cases reported, the number of hospitalisations, and the number of deaths, if indicated in the publications. Here, all FoNAO food items with low water content that were reported as associated with outbreaks were considered, even if the individual food items were not further specified or if composite food items were concerned that did not allow exact source tracking. This was done to provide an extensive database of all outbreak incidences where FoNAO commodities with low water content were implicated.
Figure 16: Flow chart of the study selection process underlying search A4. * The respective articles were then assigned to categories for inclusion or exclusion.
4.2. (B) Production methods and trade volumes of FoNAO with low water content from third countries to the European Union

The search within thematic area (B) aimed at illustrating both the primary production and processing steps for the food items identified during the search within thematic area (A). The focus was set on critical points (CPs), indicating susceptibility to microbial contamination. If applicable, CPs were collected from the literature that were indicated in association with the pathogens shown in the tables produced for thematic area (A).

For all tables, the classification of commodities of FoNAO was included as presented in Table 1 of this report and following the categorization of FoNAO commodities set up by EFSA. The selected food items and pathogens are based on the outcome of the searches within thematic area (A). Tables 20 and 21 show the categories and items of FoNAO with low water content associated with pathogenic bacteria and parasites, respectively. These items were considered for the literature searches, by themselves and in conjunction with the associated pathogen(s). The search for CPs was primarily based on the production procedures of a specific food item; in addition, the food item and the pathogen were searched for in combination.

The CPs were identified from publications like HACCP documents, guidance documents and reports as well as scientific publications. The CPs listed in the documents describing the production and processing procedures for a given food item were extracted. A clear link between a CP and a specific pathogen was not frequently found in the relevant documents. If such an association was reported, the pathogen is included in the list.

The CPs are depicted in a harmonized way. In a number of cases not the original description of the CP in the production process according to the cited document is given but a simplified term was chosen. It is thus possible to identify the most important and most critical points and procedures during the production of a specific food item based on the frequency of their occurrence in the cited documents.

For the primary production and processing steps, two separate tables (Tables 22 and 23 in appendix B) were produced. Primary production was defined as commodity growing and harvesting on the field, whereas all subsequent steps starting from transport were defined as processing. Resulting from the search strategy, Tables 22 and 23 focus on the depiction of CPs reported for the production and processing procedures of a specific food item.

Each CP is given in a separate line; in addition, the publishing organization and the country of publication (including the classification EU vs. non-EU) are shown. Generally, production and processing procedures have been mainly described for non-EU countries, which is reflected in the listed entries of which roughly ¾ originate from non-EU documents.

Table 22 indicates the CPs identified in the primary production process (i.e. until harvest) of specific food items. The following CPs were identified in primary production: cleaning, cultivation, drying, environment, equipment, fecal matter, harvesting, irrigation, manure, packaging, personnel, processing, soil, storage, transport, and water (in total 16 CPs). Contamination through “fecal matter” was the most frequently identified CP. The harvesting procedure was determined to be equally important in order to avoid the contamination of the analyzed food items. Also manure is a crucial CP, followed by irrigation, cultivation and the environment (e.g. production site, crop rotation). For some food items, a predominant CP was clearly determined. “Fecal matter” was identified as the predominant source of microbial contamination in seeds. For “ready-to-eat dried seeds” (Category 28) irrigation, manure, soil and fecal matter were listed as potential sources of contamination with – in particular – Salmonella spp., similar to “seeds for sprouting”, for which harvesting was listed as additional CP.

Table 23 shows the CPs in the processing procedures, starting from the transport of the commodity until the final, and, if applicable, packed product. Storage was established as the most frequent CP linked to virtually all food items under investigation. Raw material and water were important for most
food items, followed by processing and packaging, also shown to be universally valid. Drying was critical primarily for spices, pepper, herbs, but also in chocolate products production. Some CP was specific to a particular food item, e.g. sprouted seeds or milling of cereals. Concerning sprout production, also harvesting of the sprouts is critical, in addition to the harvesting of the seeds used for sprouting (see primary production).

Table 24 in appendix B gives an overview of examples of guideline documents and standards found during the literature research. Almost all of the guideline documents are of non-EU origin, again reflecting that the investigated FoNAO with low water content is mostly produced and – at least partially – processed outside the EU.

Table 25 in appendix B shows trade volumes from third countries into the EU of FoNAO with low water content that have been reported in association with biological hazards in the last ten years (2002-2011). The trade volumes for the corresponding food items were extracted from the Eurostat-Database (http://epp.eurostat.ec.europa.eu/newxtweb/). The appropriate categories for the selected food items were combined according to the product description. Significant amounts of relevant FoNAO with low water content are imported into the EU.

4.3. (C) Consumption of FoNAO with low water content

The search strategy applied for search C1 (consumption habits) and search C2 (population group) is illustrated in Figure 6. This strategy was used for retrieving data relating to food items of both high and low water content to avoid redundancy. However, of the 213 abstracts considered as potentially relevant, only 31 were selected for full text checking. Finally, only eight articles were maintained after the full text quality check and were used for data extraction into tables of both Lot 1 and 2.

Data from relevant articles were extracted into Table 26 in appendix C. However, scientific publications contained mainly information on fruit and vegetable consumption in general but in most cases did not report on consumption patterns regarding individual items of FoNAO. Screening the websites of major pan-European nutrition studies (HELENA Health Lifestyle in Europe by Nutrition in Adolescence, http://www.helenastudy.com/; HBSC Health behaviour in school aged children, http://www.hbsc.org/publications/journal/; ProChildren project http://www.prochildren.org/; ISAFRUIT, http://www.isafruit.org) yielded information on consumer groups and regional aspects of fruit and vegetable consumption, but gave only few data relating to individual food items. Due to time and resource limitation it was not possible to access the raw data of the nutrition studies by contacting individual researchers. The most detailed compilation of consumption data of FoNAO is given in the Comprehensive European Food Consumption Database by EFSA (http://www.efsa.europa.eu/en/foodcdb/date - foodcdb/date - fooddb.htm), which in accordance with EFSA was not considered in the present study since it is internally available by EFSA.
Figure 17: Flow chart of the study selection process underlying search C1 (consumption habits) and search C2 (consumption by population groups).
4.4. (D) Ranking of food/Pathogen combinations

The present study explored multiple aspects of biological contamination of FoNAO with low water content, aimed at identifying the most critical FoNAO/pathogen combinations regarding food safety. Thus, research area D was dedicated to evaluating the data collected in the previous research areas and forming a conclusive synopsis of all search results.

However, while the various data retrieved via searches A, B and C were all considered for the final evaluation of food/pathogen combinations, data on outbreak incidences formed the primary basis for an evaluation regarding their overall importance. The occurrence and severity of outbreaks are solid indications of a health concern, which is of utmost importance for human societies. Similarly, estimated health risks of the hazards for the consumer were consensually considered as an important criterion for prioritisation of food safety issues in a survey that was performed among various food safety-relevant stake holder groups (Van Boxstael et al., 2012).

Tables 27 to 29 in appendix D present the FoNAO/pathogen combinations identified that were associated with outbreaks involving the ten highest numbers of cases, the ten highest numbers of hospitalisations, and involving cases of death in EU countries. Correspondingly, Tables 30 to 32 in appendix D show food/pathogen combinations with the ten highest numbers of outbreak cases and hospitalisations, and involving cases of death in non-EU countries. Outbreaks caused by pathogenic bacteria, viruses and parasites were treated individually. Outbreak data were collected globally, from reports originating from both EU and non-EU regions. For the scope of the evaluation, outbreaks were listed separately for EU and non EU countries according to the outbreak location. Regarding EU data, EFSA/BIOMO data from EUSR were not considered, since it is internally available by EFSA; and only literature data was used for this purpose. It is notable that most publications on outbreaks in non EU regions are dealing with outbreaks in the United States, which may also be due to language restrictions.

In the EU (Tables 27-29), the outbreaks involving the highest numbers of outbreak cases (including 50 cases of death) were caused by pathogenic E. coli on/in sprouts; comprising two linked outbreaks in Germany and France, which involved travel-related cases in other European and non-European countries. Fenugreek seeds imported from Egypt were identified as the common source for the French and German outbreaks. Furthermore, several outbreaks involving Salmonella spp. on/in sprouts had high numbers of cases and hospitalisations and included also one case of death. Multiple outbreaks involving rice/ Bacillus cereus were reported for Germany and the Netherlands. Singular outbreak cases that ranged among the ten highest numbers of cases concerned the combinations baby corn/Shigella sonnei, white pepper/Bacillus cereus, buckwheat/Bacillus cereus, aniseed/Salmonella Agona, almonds/Salmonella enteritidis, curry/Bacillus cereus, and hemp flour/Salmonella Montevideo. Virus related outbreaks involved only highly processed and composite FoNAO products (i.e. bakery products (doughnuts)/Hepatitis A virus, Sushi rice/Norovirus, and sweets and chocolate/Norovirus), which were not considered in the ranking.

In non-EU countries (Tables 30 and 31), the highest numbers of outbreak cases involving hospitalisations were caused by Salmonella on/in sprouts (alfalfa and bean sprouts) in outbreaks in the USA and in Canada. Multiple sprout-related outbreaks, however with fewer cases, were also caused by pathogenic E. coli, including travel-related cases within the French and German outbreaks in 2011 that were linked to fenugreek seeds. Outbreak incidences caused by other combinations involved black and red pepper/Salmonella Montevideo, Bamboo shoots/Clostridium botulinum, baby corn/Shigella sonnei, and nuts (pine nuts, almonds, hazelnuts) combined with Salmonella spp. or pathogenic E.coli. No virus-related outbreaks were reported for non-EU countries that were related to FoNAO with low water content.

Supporting publications 2013:EN-403

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The FoNAO/pathogen combinations listed in Tables 27 to 32 formed the primary basis for the subsequent prioritisation regarding multiple qualitative factors. The focus of this prioritisation analysis was on ready-to-eat, unprocessed FoNAO, excluding composite products. Hence, FoNAO items belonging to category 27 (“other dry legumes, cereals, edible seeds and grains, flours and products thereof”) and 33 (beverages, including composite products such as chocolate made of the basic food commodities) were excluded from the evaluation process because no unambiguous food item/pathogen association could be formed. It has to be considered that source tracking to individual FoNAO items is not always possible with composite and highly processed products such as chocolate and bakery products, and that ingredients of complex food items may include those of animal origin.

Tables 10 and 11 presented below show the food/pathogen combinations that have been attributed level 1 to 3 priorities. Again, separate evaluations were done for EU and non EU countries. Priority groups were defined based on multiple factors specified within the criteria “outbreaks”, “pathogen prevalence”, “production”, and “food/pathogen interaction” (see Tables 10 and 11 and Chapter 3.6). The approach followed for evaluating the importance of FoNAO/pathogen combinations regarding food safety used a qualitative prioritisation scheme. Specifically, FoNAO/pathogen combinations were rated as highly critical (A), critical (B) or moderately critical (C) with respect to food safety regarding multiple aspects, including outbreaks of disease, production and processing procedures, hazard prevalence in the food commodity concerned, and food/pathogen interaction (see also Chapter 3.6). FoNAO/pathogen combinations that were rated as highly critical regarding at least three criteria (including outbreaks), were assigned highest priority. Combinations that showed two highly critical characteristics (with outbreaks being rated either highly critical or critical) were allocated to priority group 2. If a combination had one highly critical characteristic together with some other critical factor, priority level 3 was applied. Defining priority groups was preferred over a ranking of all food/pathogen combinations in a numeric order, because the information corresponding to the classification criteria was heterogeneous and varied for the various combinations.

For both EU and non EU countries, highest priority was assigned to the FoNAO/pathogen combinations sprouts/Salmonella spp. and sprouts/pathogenic E.coli. Besides other E.coli-related outbreaks, two linked outbreaks in Germany and France that were traced back to E. coli O104:H4 on/in fenugreek seeds affected several European and non-European countries, involving high numbers of cases and deaths. Multiple outbreaks within and outside the EU were associated with Salmonella spp. on alfalfa and bean sprouts, with high numbers of cases and hospitalisations including one case of death. In addition, critical factors regarding food safety have been reported in the areas production and food/pathogen interaction for the FoNAO category “seeds for sprouting and sprouted seeds”. Detection of Salmonella spp. on/in seeds for sprouting and sprouted seeds has also been documented.

Priority two for EU countries was attributed to the combination of rice with Bacillus cereus. High prevalences (up to 100%) of Bacillus cereus and Bacillus cereus like organisms have been documented in rice and products thereof, together with multiple outbreaks associated with this combination. However, one has to take into consideration that Bacillus cereus is a spore forming pathogen, and that it has been indicated that its emetic toxin is produced only by a minority of B.cereus strains (Häggblom et al. 2002). This combination was graded priority two in spite of highly critical factors regarding production, prevalence, and food/pathogen interaction, because no hospitalisations or cases of death have been involved in outbreaks. However, considering the enormous global consumption of this food commodity and the fact that pathogenicity of Bacillus cereus depends on toxin expression also supports the grading as priority 2.

FoNAO/pathogen combinations allocated to priority group two for EU countries include baby corn combined with Shigella sonnei. A high number of cases involving hospitalisations was reported for an outbreak in Denmark, and critical factors have been identified regarding production and food/pathogen interaction (Shigella spp. being highly infectious). Possibly, this outbreak was related to an outbreak in

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Australia also involving *Shigella sonnei* and baby corn, which, however, was less severe. Hence, *Shigella sonnei* and baby corn was assigned priority three for non-EU countries. For EU countries, priority 3 grading was allocated to nuts/*Salmonella* spp. based on a cluster of outbreak cases in Sweden with highly probable associations to almond consumption (but no records of hospitalisations), and because of multiple risk factors regarding production, prevalence, and food/pathogen interaction.

In non-EU countries, nuts have been implicated in multiple outbreaks caused by *Salmonella* spp. and pathogenic *E.coli*, involving high numbers of cases and hospitalisations. Several studies report on *Salmonella* prevalence on/in nuts, and a high persistence of both *Salmonella* spp. and *E.coli* on/in nuts has been found in inoculation studies. Since similarities among various kinds of nuts (e.g. almonds, pine nuts, pecan nuts or hazelnuts) could be seen regarding the critical steps in production and processing as well as the colonization behaviour of bacterial pathogens, nuts in general were considered as a commodity for classifying the FoNAO/pathogen combinations. Hence, combinations of nuts with *Salmonella* spp. and with pathogenic *E.coli* were assigned grade 2 priority for non-EU countries.

For non-EU countries, pepper (black/red) combined with *Salmonella* spp. has been allocated to priority group three based on a single but severe outbreak case and because of the frequent detection of *Salmonella* spp. on/in spices including pepper. Sixteen studies report the occurrence of *Salmonella* spp. in spices and dry herbs, three out of which relate to *Salmonella* spp. on/in pepper. Furthermore, pepper is susceptible to bacterial contamination during specific production steps that involve drying on the ground potentially without proper hygienic considerations. Food safety risks may also be introduced by the fact that unlike other herbs and spices pepper is frequently added to meals after cooking (and thus is not heated).
Table 10: Ranking of food/pathogen combinations in EU countries based on criteria related to outbreaks\(^1\), pathogen prevalence and food/pathogen interaction, and to the production of the food item(s) concerned. “High number” means position in top ten list (Tables 30-32). For details on the classification scheme applied ((A) “highly critical”, (B) “critical”, (C) “moderately critical”) see methods section. NR= not reported.

| FoNAO Category | Food item | Pathogen | Outbreaks | Production | Prevalence | Food/pathogen interaction | Priority group |
|----------------|-----------|----------|-----------|------------|------------|---------------------------|----------------|
| 28 Seeds for sprouting and sprouted seeds | Sprouts (fenugreek seeds) | *E. coli* O104:H4 | (A) Two linked outbreaks in Germany and France with travel-related outbreaks in other EU countries plus Norway (4031 cases, 51 deaths) related to the consumption of fenugreek seeds imported from Egypt | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for microbial contamination of seeds for sprouting and sprouted seeds. | NR | (A) *E. coli* can attach to alfalfa sprouts in a serovar-dependent manner. It grows at 20, 30 and 35 °C. | 1 |
| 28 Seeds for sprouting and sprouted seeds | Sprouts (alfalfa and bean sprouts) | *Salmonella* spp. | (A) High numbers of cases and hospitalisations in multiple outbreaks | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for microbial contamination of seeds for sprouting and sprouted seeds. | (A) Two studies report on *Salmonella* spp. detection in seeds for sprouting and sprouted seeds. | (A) *Salmonella* spp. can attach to alfalfa sprouts (independent of serovar). It grows at 20, 30 and 35 °C and during seed sprouting. | 1 |
| 24 Cereals and dry legumes | Corn (baby corn) | *Shigella sonnei* | (B) Outbreak in Denmark with high number of cases and hospitalisations, possibly related to outbreak in Australia | (A) Multiple factors related to production (harvesting) and processing (packaging, transport, storage) are critical for microbial contamination of baby corn. | NR | (A) *Shigella* spp. are highly communicable and have a relatively low infectious dose of 10 to 500 organisms (Kothary and Babu, 2001). | 2 |
| 25 Rice | Rice | *Bacillus cereus* | (B) High numbers of cases in multiple outbreaks. | (A) Multiple factors related to processing (drying, cleaning, equipment, storage, water) are critical for microbial contamination of rice. | (A) High prevalences of *Bacillus cereus* and *Bacillus cereus* like organisms in rice and products thereof have been reported in multiple studies. | (A) *Bacillus cereus* can internalise in cooked rice; growth depends on storage temperature and pH. | 2 |
| FoNAO Category          | Food item          | Pathogen  | Outbreaks                                                                 | Production                                                                 | Prevalence                                                                 | Food/pathogen interaction                                                                 | Priority group |
|------------------------|--------------------|-----------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|----------------|
| 31 Nuts and nuts products | Nuts (almonds)    | *Salmonella* spp. | (C) Cluster of 15 outbreak cases in Sweden with high probability of associations with the consumption of almonds | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for contamination of nuts with *Salmonella*. | (A) Several studies report on *Salmonella* prevalence on/in nuts. | (A) *Salmonella* spp. in pecan granules increased by 6.31 log cfu/g during 45 hrs when incubated at 37 °C; *Salmonella* Enteritidis decreased by 0.4 to 3.1 log cfu/g during 550 days when incubated at various temperatures. | 3              |

*Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking.*
Table 11: Prioritisation of food/pathogen combinations in non-EU countries based on criteria related to outbreaks\(^1\), pathogen prevalence and food/pathogen interaction, and to the production of the food item(s) concerned. “High number” means position in top ten list (Tables 30-32). For details on the classification scheme applied ((A) “highly critical”, (B) “critical”, (C) “moderately critical”) see methods section. NR= not reported.

| FoNAO Category | Food item | Pathogen | Outbreaks | Production | Prevalence | Food/pathogen interaction | Priority group |
|----------------|-----------|----------|-----------|------------|------------|---------------------------|----------------|
| 28 Seeds for sprouting and sprouted seeds | Sprouts (alfalfa and bean sprouts) | Salmonella spp. | (A) High number of cases and hospitalisations in multiple outbreaks. | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for microbial contamination of seeds for sprouting and sprouted seeds. | (A) Two studies report on Salmonella spp. detection in seeds for sprouting and sprouted seeds. | (A) Salmonella can attach to alfalfa sprouts (independent of serovar). It grows at 20, 30 and 35 °C and during seed sprouting. | 1 |
| 28 Seeds for sprouting and sprouted seeds | Sprouts (alfalfa, and clover sprouts, fenugreek seeds) | pathogenic E.coli | (A) Travel-related outbreak cases (Norway, Switzerland, 6 U.S. states, Canada) linked to French and German outbreaks related to sprout consumption (13 cases, 1 death outside the EU); two outbreaks in the U.S. involving high numbers of cases and hospitalisations | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for microbial contamination of baby corn. | NR | (A) E. coli can attach to alfalfa sprouts in a serovar-dependent manner. It grows at 20, 30 and 35 °C. | 1 |
| 31 Nuts and nuts products | Nuts (almonds, pine nuts, hazelnuts,....) | Salmonella spp. | (B) High numbers of cases and hospitalisations in a multi-state outbreak in the U.S. related to the consumption of Turkish pine nuts. | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for contamination of nuts with Salmonella and pathogenic E.coli. | (A) Several studies report on Salmonella prevalence on/in nuts. | (A) Salmonella spp. in pecan granules increased by 6.31 log cfu/g during 45 hrs when incubated at 37 °C; Salmonella Enteritidis decreased by 0.4 to 3.1 log cfu/g during 550 days when incubated at various temperatures. | 2 |
| FoNAO Category | Food item | Pathogen | Outbreaks | Production | Prevalence | Food/pathogen interaction | Priority group |
|---------------|-----------|----------|-----------|------------|------------|--------------------------|----------------|
| 31 Nuts and nuts products | Nuts (almonds, pine nuts, hazelnuts…) | pathogenic E. coli | (B) High numbers of cases and hospitalisations in a multi-state outbreak in the U.S. related to the consumption of hazelnuts. | (A) Multiple factors related to production (germination, raw material, fecal matter, manure, harvesting, irrigation, water) and processing (packaging, storage) are critical for contamination of nuts with Salmonella and pathogenic E. coli. | NR | (A) E. coli O157:H7 in walnut kernels decreased by 2.6 log cfu/g during 105 days when incubated at 23°C. | 2 |
| 24 Cereals and dry legumes | Corn (baby corn) | Shigella sonnei | (C) Outbreak in Australia with a high number of cases, possibly related to outbreak in Denmark. | (A) Multiple factors related to production (harvesting) and processing (packaging, transport, storage) are critical for microbial contamination of baby corn. | NR | (A) Shigella spp. are highly communicable and have a relatively low infectious dose of 10 to 500 organisms (Kothary and Babu, 2001). | 3 |
| 32 Spices and dry powdered herbs | Pepper (black/red) | Salmonella spp. | (B) High number of cases and hospitalisations in a multi-state outbreak in the U.S. | (B) Specific hygiene-related factors in processing (drying-spreading on the ground without cover, storage, cleaning, processing, water, packaging) are critical for bacterial contamination of pepper. | | (A) Six studies report on Salmonella spp. detection in spices and dry powdered herbs. Three studies report on Salmonella spp. detection in red and/or black pepper. | 3 |

1Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking.
5. Conclusions

Biological hazards linked to FoNAO are of considerable public concern, which is reflected in the abundant scientific and grey literature retrieved in the present study. Our extensive review addressing pathogenic bacteria, viruses, and parasites associated with FoNAO with low water content yielded 7710 scientific literature entries in the study database (relating to FoNAO with both high and low water content), together with 134 grey literature documents (relating specifically to FoNAO with low water content). 315 documents were finally selected for data extraction from full texts into structured tables of Lot 2. Information referring to pathogen identification and characterisation and to the consumption of FoNAO was derived mainly from scientific publications, while data relating to the production and processing of FoNAO were predominantly contained in grey literature sources.

Bacterial pathogens that were reported in association with FoNAO with low water content were similar for EU and non-EU countries, comprising representatives of the genera Bacillus, Campylobacter, Clostridium, Cronobacter, Enterobacter, Salmonella, Shigella as well as Klebsiella pneumoniae, Listeria monocytogenes Pseudomonas aeruginosa, Staphylococcus aureus and Yersinia enterocolitica. However, of in total 103 associations on biological hazards identified on/in FoNAO with low water content, 29 and 24 were on combinations with Cronobacter spp. and Salmonella spp., respectively. Cronobacter spp. included C. dublinensis, C. malonaticus, C. muytjensii, and C. sakazakii/ronobacter, and Salmonella spp. comprised serovars Agona, Enteritidis, Infantis, Kentucky, Muenchen, Newport, Typhi, Typhimurium, and unspecified serovars. No viruses have been described on/in FoNAO with low water content. Parasites that have been described in association with FoNAO with low water content include Cryptosporidium spp, Enterocytozoon bieneusi, Giardia spp., and Microsporidia spores.

Studies on food/pathogen interaction have evidenced attachment and/or biofilm formation for pathogenic E.coli, Listeria monocytogenes, and Salmonella spp. on FoNAO with low water content. In addition, internalisation into FoNAO with low water content has been reported for Bacillus cereus, E.coli, several Salmonella serovars, and Listeria monocytogenes. This implicates a critical food/pathogen interaction regarding food safety, which has to be considered when evaluating their importance regarding food safety issues.

Critical steps in the production of FoNAO items were identified primarily based on GAP, GMP and HACCP documents and other producer guidelines, and included cleaning, cultivation, drying, environment, equipment, fecal matter, harvesting, irrigation, manure, packaging, personnel, processing, soil, storage, transport, and water. Contamination through “fecal matter” was the most frequently identified critical point (CP). Regarding processing of FoNAO, raw material and water were important CPs for most food items, followed by processing and packaging. Drying was critical primarily for spices, pepper, herbs, but also chocolate products production. In most cases, multiple points in primary production and/or processing were considered as equally critical regarding food safety issues. However, in some cases a single dominant point was highlighted.

The number and severity of outbreaks of disease caused by the consumption of contaminated FoNAO provided the basis for a primary evaluation of the FoNAO/pathogen combinations identified within the study. Additional qualitative criteria relating to pathogen prevalence and their colonization behaviour, and to the production of FoNAO items were included to define three priority groups of critical FoNAO/pathogen combinations for EU and non-EU countries, respectively.

For both EU and non EU countries, highest priority was assigned to the FoNAO/pathogen combinations sprouts/Salmonella spp. and sprouts/pathogenic E.coli, based on multiple outbreaks involving high numbers of cases and hospitalisations and including cases of death, and because of several additional critical factors regarding food safety.
Priority two for EU countries was attributed to the combination of rice with *Bacillus cereus* based on high prevalences (up to 100%) of the bacterial agent in rice and products thereof, together with multiple outbreaks associated with this combination. FoNAO/pathogen combinations allocated to priority group two for EU countries also include baby corn combined with *Shigella sonnei* based on cases involving hospitalisations and critical factors regarding production and infectivity. In non-EU countries, nuts have been implicated in multiple outbreaks caused by *Salmonella* spp. and pathogenic *E.coli*, involving high numbers of cases and hospitalisations, which thus were assigned grade two priority. For EU countries, however, priority three grading was allocated to nuts/*Salmonella* spp. based on a single cluster of reported outbreak cases. For non-EU countries, baby corn/*Shigella sonnei* and pepper (black/red)/*Salmonella* spp. was allocated to priority group three.

This report provides a broad scientific database that will be instrumental in the conceptualisation of specific measures for improving the safety of FoNAO with low water content. Ultimately, it may contribute to the prevention and a better control of food borne diseases.
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Food of plant origin with low water content

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Table 12: Bacterial pathogens and parasites identified in association with FoNAO with low water content, listed in alphabetical order. “Country” signifies the place where the food commodity was found in association with the biological contaminant (e.g. site of survey or screening).

| Pathogen | FoNAO Category | FoNAO number | Food item(s) | Country/ies | Reference(s) |
|----------|----------------|--------------|--------------|-------------|--------------|
| Bacillus cereus | Cereals and dry legumes | 24 | Wheat flour, wheat, job’s tears (*Coix lacryma jobi*), cereal, barley, wheat grain | Turkey, Argentina, Australia, Korea | Segun et al., 2012; Fangio et al., 2010; Alp et al., 2008; Berghofer et al., 2003; Park et al., 2008; Eglezos 2010a |
| Rice | | 25 | Rice, glutinous rice, brown rice, fried rice with vegetable/Chinese-Style | Nigeria, Italy, Korea, Belgium, Sri Lanka | Isara et al., 2010; Bonerba et al., 2010; Park et al., 2008; Delbrassinne et al, 2012; Perera and Ranasinghe 2012 |
| Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | | 27 | Bran, flour, wheat germ, biscuits (Infant food) | Australia, Korea | Berghofer et al., 2003; Kim et al., 2011a |
| Seeds for sprouting and sprouted seeds | | 28 | Sprouts (*Phaseolus vulgaris*) | Venezuela | Cava et al., 2009 |
| Spices and dry powdered herbs | | 32 | Herbs, dried red pepper, spices, red pepper powder, saffron | Italy, Korea, India, Spain, United Kingdom | Vitullo et al., 2011; Choo et al., 2007; Banerjee et al., 2003; Oh et al., 2012; Little et al., 2003; Cosano et al., 2009; Sagoo et al., 2009 |
| Beverages | | 33 | Ground roasted coffee beans | Brazil | Chaves et al., 2012 |
| Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | | 37 | Rice soup (Infant food), other food, ready to eat food, tarhana | Korea, India, United Kingdom, Turkey | Kim et al., 2011a; Roy et al., 2007; Little et al., 2003; Ucar et al., 2011; Segun et al., 2012 |
| Rice | | 25 | Rice (brown, white, wild type, black and rice mixtures) | USA | Ankolekar et al., 2009 |
| Pathogen                      | FoNAO Category                                                                 | FoNAO number | Food item(s)                                                                 | Country/-ies     | Reference(s)                                |
|------------------------------|--------------------------------------------------------------------------------|---------------|------------------------------------------------------------------------------|------------------|---------------------------------------------|
| **Bacillus cereus like organism** | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Cereal products, breakfast cereals, raw cereals, pre-mixed drinks, breakfast cereals | Malaysia         | Lee et al., 2009                            |
| **Bacillus cereus spp. group** | Rice                                                                            | 25            | Rice                                                                         | Denmark          | Rosenquist et al., 2005                     |
|                              | Pasta                                                                           | 26            | Pasta                                                                        | Denmark          | Rosenquist et al., 2005                     |
| **Campylobacter coli**       | Seeds for sprouting and sprouted seeds                                          | 28            | Mung bean sprout                                                             | Malaysia         | Chai et al., 2007                           |
| **Campylobacter jejuni**     | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Vhuswa                                                                      | South Africa     | Potgieter et al., 2005                     |
|                              | Seeds for sprouting and sprouted seeds                                          | 28            | Mung bean sprout                                                             | Malaysia         | Chai et al., 2007                           |
| **Clostridium botulinum**    | Spices and dry powdered herbs                                                   | 32            | Chamomile, linden flower (*Tilia* spp.)                                      | Argentina        | Bianco et al., 2008                         |
|                              | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37            | Aroma, sauce and gravy, thickening agents                                   | France           | Carlin et al., 2004                         |
| **Clostridium perfringens**  | Spices and dry powdered herbs                                                   | 32            | Herbs, spices                                                                | Italy, India, Argentina | Vitullo et al., 2011; Banerjee et al., 2003; Aguilera et al., 2005 |
|                              | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37            | Tarhana                                                                      | Turkey           | Segun et al., 2012                          |
|                              | Spices and dry powdered herbs                                                   | 32            | Spices, herbs                                                                | United Kingdom, Spain | Sagoo et al., 2009; Cosano et al., 2009     |
| **Cronobacter (E. agglomerans)** | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Starch, semolina, flour                                                      | Jordan           | Shaker et al., 2007                         |
| **Cronobacter dublinensis**  | Cereals and dry legumes                                                         | 24            | Lentils                                                                       | Czech Republic   | Hochel et al., 2012                         |
| Pathogen                                      | FoNAO Category                                                                 | FoNAO number | Food item(s)                                                                                     | Country/-ies          | Reference(s)          |
|----------------------------------------------|--------------------------------------------------------------------------------|---------------|-----------------------------------------------------------------------------------------------|-----------------------|------------------------|
| Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27                                                                 | Sunsk         | Korea                                                                                          | Lee et al., 2012      |
| **Cronobacter malonaticus**                  | Spices and dry powdered herbs                                                 | 32            | Pimiento                                                                                       | Czech Republic        | Hochel et al., 2012    |
| **Cronobacter malonaticus/Cronobacter dublinensis** | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37            | Instant soups                                                                                   | Slovakia              | Turcovský et al., 2011 |
| **Cronobacter maytjensis**                   | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Sunsk                                                                                          | Korea                 | Lee et al., 2012       |
| **Cronobacter sakazakii**                    | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27/3          | Oat flakes, dried adults cereals, dried infant cereals, semolina, bakery products, coconut biscuits, sunsk, dried flour or meals (Corn, soy, wheat and rice), cereal products | Czech Republic, USA, Jordan, Germany, Korea | Hochel et al., 2012; Restaino et al., 2006; Shaker et al., 2007; ECDC, 2010; Kim et al., 2008; Lee et al., 2012 |
| **Seeds for sprouting and sprouted seeds**   |                                                                                  | 28            | Poppy seed, wheat sprout, sprouts                                                               | Czech Republic, Korea | Hochel et al., 2012; Kim et al., 2009 |
| Nuts and nuts products                       |                                                                                  | 31            | Nuts                                                                                           | Slovakia              | Turcovský et al., 2011 |
| **Spices and dry powdered herbs**            |                                                                                  | 32            | Herbs and spices, pepper, caraway                                                               | United Kingdom, Czech Republic, Spain | Iversen and Forsythe, 2004; Hochel et al., 2012; Sospedra et al., 2010 |
| **Beverages**                                |                                                                                  | 33            | Herbal tea, sous, tea                                                                           | Serbia, Jordan, Slovakia | Stojanovic et al., 2011; Nassereddin and Yamani, 2005; Turcovský et al., 2011 |
| **Others**                                   |                                                                                  | 39            | Foodstuffs intended for special nutritional uses (dried dietary foods for special medical purposes intended for infants below 6 months) | Germany               | ECDC, 2008              |
| Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products)/Nuts and nut products/Dehydrated vegetables and fruit | 27/3 | Dry food ingredients other than herbs and spices (nuts, fruit, grains) | United Kingdom | Iversen and Forsythe, 2004 |

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| Pathogen                                                                 | FoNAO Category                                                                 | FoNAO number | Food item(s)                                      | Country/-ies   | Reference(s)          |
|-------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------|--------------------------------------------------|----------------|-----------------------|
| **Cronobacter sakazakii/Cronobacter dublinensis**                       | Spices and dry powdered herbs/Dehydrated vegetables and fruits                 | 32/38         | Dried vegetables and spices                      | USA            | Restaino et al., 2006 |
| **Cronobacter sakazakii/Cronobacter malonaticus**                       | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37            | Tofu                                             | Czech Republic | Hochel et al., 2012   |
| **Cronobacter sakazakii/Cronobacter dublinensis**                       | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Pastries                                         | Slovakia       | Turcovský et al., 2011|
| **Cronobacter sakazakii/Cronobacter malonaticus**                       | Seeds for sprouting and sprouted seeds                                         | 28            | Sesam seed                                       | Czech Republic | Hochel et al., 2012   |
| **Cronobacter sakazakii/Cronobacter malonaticus**                       | Spices and dry powdered herbs                                                  | 32            | Ginger                                           | Czech Republic | Hochel et al., 2012   |
| **Cronobacter sakazakii/Cronobacter dublinensis**                       | Beverages                                                                       | 33            | Chocolate products                               | Slovakia       | Turcovský et al., 2011|
| **Cronobacter sakazakii/Cronobacter malonaticus/Cronobacter muytjensi** | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37            | Instant lentil soup                              | Czech Republic | Hochel et al., 2012   |
| **Cronobacter sakazakii/Cronobacter dublinensis**                       | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Rice flour                                       | Czech Republic | Hochel et al., 2012   |
| **Cronobacter sakazakii/Cronobacter malonaticus/Cronobacter muytjensi** | Spices and dry powdered herbs                                                  | 32            | Spices                                           | Slovakia       | Turcovský et al., 2011|
| **Cronobacter sakazakii/Cronobacter malonaticus/Cronobacter muytjensi** | Seeds for sprouting and sprouted seeds                                         | 28            | Pumpkin seed                                     | Czech Republic | Hochel et al., 2012   |
| **Cronobacter sakazakii/Cronobacter muytjensi**                         | Spices and dry powdered herbs                                                  | 32            | Majoram, basil                                   | Czech Republic | Hochel et al., 2012   |
| Pathogen                        | FoNAO Category                                      | FoNAO number | Food item(s)                              | Country/-ies                  | Reference(s)                                                                 |
|--------------------------------|------------------------------------------------------|---------------|-------------------------------------------|------------------------------|-----------------------------------------------------------------------------|
| *Cronobacter* spp.             | Cereals and dry legumes                              | 24            | Breakfast cereals, grains                 | Ireland, Korea               | Molloy et al., 2009; Chon et al., 2012                                      |
|                                | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Grains and beans, sunsik, dried cereals   | Korea, Netherlands          | Kim et al., 2011b; Lee et al., 2012; Kandhai et al., 2010                  |
|                                | Seeds for sprouting and sprouted seeds               | 28            | Sprouts                                  | Swiss                        | Althaus et al., 2012                                                      |
|                                | Spices and dry powdered herbs                        | 32            | Herbs and spices, spices and dried herbs, sage, dried spices, thyme, chamomile, anise, fennel, mixed Spices, liquorice | Jordan, Ireland, Korea, Netherlands | Jaradat et al., 2009; Baumgartner et al., 2009; Chon et al., 2012; Kandhai et al., 2010 |
|                                | Seeds for sprouting and sprouted seeds/ Fresh herbs/ Leafy greens eaten raw as salads | 28/16/15      | Sprouts/fresh herbs/salads               | Ireland                      | Baumgartner et al., 2009                                                  |
| *Enterobacter cloaca*          | Spices and dry powdered herbs                        | 32            | Spices                                   | Spain                        | Sospedra et al., 2010                                                     |
| *Enterobacter gergoviae*       | Spices and dry powdered herbs                        | 32            | Spices                                   | Spain                        | Sospedra et al., 2010                                                     |
| *Klebsiella pneumoniae*        | Nuts and nuts products                               | 31            | Almond                                   | Libya                        | Ghenghesh et al., 2005                                                    |
| Beverages                      | Tamarind                                             | 33            | Tamarind                                 | Jordan                       | Nasserедин и Yaman, 2005                                                   |
| *Listeria monocytogenes*       | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Confectionery products and pastes, bakery products, flour, cereals and meals, pastries, cakes, homserim dessert | Hungary, Lithuania, Portugal, Luxembourg, Croatia, Turkey, Slovenia, Ireland | ECDC, 2008; Mena et al., 2004; ECDC, 2009; Uhitil et al., 2004; Cokal et al., 2012 |
|                                | Seeds for sprouting and sprouted seeds               | 28            | Broccoli sprouts, alfalfa sprouts, red radish sprouts, sprouts, seeds                    | Korea, Hungary               | Waje et al., 2009; ECDC, 2009                                              |
|                                | Nuts and nuts products                               | 31            | Mixed nuts                               | Australia                    | Eglezos 2010b                                                              |
|                                | Spices and dry powdered herbs                        | 32            | Spices and herbs                         | Italy                        | ECDC, 2008                                                                 |
|                                | Nuts and nuts products/Dehydrated vegetables and fruit | 31/38         | Dried fruits (walnut, hazelnut, pine-nut, sultana, apricot)                         | Portugal                     | Mena et al., 2004                                                         |
| *Pseudomonas aeruginosa*       | Rice                                                 | 25            | Rice                                     | Nigeria                      | Isara et al., 2010                                                        |
| Pathogen                      | FoNAO Category                      | FoNAO number | Food item(s)                      | Country/-ies                  | Reference(s)                           |
|-------------------------------|-------------------------------------|---------------|-----------------------------------|-------------------------------|----------------------------------------|
| Nuts and nuts products        |                                    | 31            | Almond                            | Libya                         | Ghenghesh et al., 2005                 |
| Beverages                     |                                    | 33            | Sous                              | Jordan                        | Nasserreddin and Yamani, 2005          |
| Salmonella Agona              | Spices and dry powdered herbs       | 32            | Ground red pepper                 | Jordan                        | Erol et al., 2009                      |
| Salmonella Bredeney           | Spices and dry powdered herbs       | 32            | Spices and herbs, black pepper    | Slovakia, Turkey              | ECDC, 2008; Erol et al., 2009          |
| Salmonella enterica           | Spices and dry powdered herbs       | 32            | Red pepper, black pepper          | Japan                         | Hara-Kudo et al., 2006                 |
| Salmonella Enteritidis        | Other dry legumes, cereals, edible  | 27            | Bakery products, confectionery    | Spain, Hungary, Lithuania,    | ECDC, 2008                             |
|                              | seeds and grains, flours and products thereof (processed products) |               | products and pastes, bakery products (cakes), noodles | Slovakia, Turkey |                       |
| Nuts and nuts products        |                                    | 31            | Almond                            | USA                           | Bansal et al., 2010                    |
| Spices and dry powdered herbs |                                    | 32            | Spices and herbs                  | Netherlands                   | ECDC, 2008                             |
| Salmonella Infantis           | Beverages                           | 33            | Chocolate                         | Hungary                       | ECDC, 2008                             |
| Salmonella Kentucky           | Spices and dry powdered herbs       | 32            | Red pepper powder                 | Turkey                        | Erol et al., 2009                      |
| Salmonella Muenchen           | Nuts and nuts products              | 31            | Almond                            | USA                           | Bansal et al., 2010                    |
| Salmonella Newport            | Nuts and nuts products              | 31            | Almond                            | USA                           | Bansal et al., 2010                    |
| Salmonella spp.               | Cereals and dry legumes             | 24            | Maize; ugali, maize; porridge, wheat grass, wheat grain | Kenya, India, Australia       | Muoki et al., 2008; Titarmare et al., 2009; Eglezos 2010a |
|                              | Other dry legumes, cereals, edible  | 27            | Mandazi; chapati, maize flour     | Kenya, Malawi, South Africa   | Muoki et al., 2008; Taulo et al., 2008; Potgieter et al., 2006 |
|                              | seeds and grains, flours and products thereof (processed products) |               | porridge, vhuswa                  |                               |                                        |
| Nuts and nuts products        |                                    | 31            | Nuts, almond, raw almond, inshell almond, almond kernel | Australia,USA | Eglezos et al., 2008; Danyluk et al., 2006; Bansal et al., 2010; Lambertini et al., 2012; Danyluk et al., 2007 |
| Beverages                     |                                    | 33            | Tamarind, sous                    | Jordan                        | Nasserreddin and Yamani, 2005          |
| Beverages                     |                                    | 33            | Tamarind, sous                    | Jordan                        | Nasserreddin and Yamani, 2005          |

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| Pathogen                        | FoNAO Category                                                                 | FoNAO number | Food item(s)                                      | Country/ies               | Reference(s)                          |
|--------------------------------|----------------------------------------------------------------------------------|--------------|--------------------------------------------------|---------------------------|---------------------------------------|
|                                | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37           | Other food, beans                                | India, Malawi             | Roy et al., 2007; Taulo et al., 2008 |
|                                | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27           | Cereals and meals, bakery products (desserts), noodles | Luxembourg, Spain, Ireland, Slovakia, Germany | ECDC, 2009                            |
|                                | Seeds for sprouting and sprouted seeds                                           | 28           | Seeds, linseed (flax), sunflower, melon (egusi), seeds; sprouted, alfalfa seeds, seeds mixed, sesam seed | Netherlands, United Kingdom + Import, Romania, Germany | ECDC, 2009; Willis et al., 2009       |
|                                | Nuts and nuts products                                                           | 31           | Mixed nuts                                       | United Kingdom            | Little et al., 2010; Little et al., 2009 |
|                                | Spices and dry powdered herbs                                                    | 32           | Spices, spices and herbs, spices, curry          | Hungary, India, United Kingdom, Netherlands, Sweden | ECDC, 2009; Little et al., 2003; Mankee et al., 2005; ECDC, 2008; Sagoo et al., 2009 |
|                                | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37           | Halvah, sesam paste                              | Germany                   | Brockmann et al., 2004                |
| **Salmonella Typhi**           | Rice                                                                              | 25           | Rice                                             | Nigeria                   | Isara et al., 2010                    |
| **Salmonella Typhimurium**     | Nuts and nuts products                                                           | 31           | Almond                                           | USA                       | Bansal et al., 2010                   |
|                                | Spices and dry powdered herbs                                                    | 32           | Spices and herbs                                 | Netherlands               | ECDC, 2008                            |
| **Shigella sonnei**            | Rice                                                                              | 25           | Rice                                             | Nigeria                   | Isara et al., 2010                    |
|                                | Spices and dry powdered herbs                                                    | 32           | Herbs                                            | Spain                     | Sospedra et al., 2010                 |
| **Shigella spp.**              | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27           | Vhuswa                                           | South Africa              | Potgieter et al., 2005                |
|                                | Spices and dry powdered herbs                                                    | 32           | Spices, herbs                                    | Spain                     | Sospedra et al., 2010                 |
| **Staphylococcal enterotoxins**| Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27           | Confectionery products and pastes, cereals and meals | Slovakia, Ireland, Luxembourg | ECDC, 2009                            |
|                                | Beverages                                                                        | 33           | Chocolate                                        | Luxembourg                | ECDC, 2009                            |

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| Pathogen                          | FoNAO Category                                | FoNAO number | Food item(s)                                                                 | Country/-ies              | Reference(s)                          |
|----------------------------------|-----------------------------------------------|---------------|------------------------------------------------------------------------------|---------------------------|---------------------------------------|
| **Staphylococcus aureus**        | Cereals and dry legumes                        | 24            | Wheat                                                                       | Turkey                    | Alp et al., 2008                       |
|                                  | Rice                                           | 25            | Sticky rice, nem chao, rice cakes with filling, rice cake, rice cakes without filling, kimbab, korean snack | Japan, Vietnam, Bagladesch, Korea | Huong et al., 2010; Oh et al., 2007      |
|                                  | Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | 27            | Hosmerim dessert, maize flour porridge, creami-cake, buckwheat vermicelli, powdered infant formula milk, cream-bread, bread, cereal based food | Turkey, Malawi, Nigeria, Korea, China, USA | Olasupo et al., 2002; Cokal et al., 2012; Taulo et al., 2008; Oh et al., 2007; Wang et al., 2012 |
|                                  | Spices and dry powdered herbs                  | 32            | Spices, herbs                                                               | Spain, India              | Banerjee et al., 2003; Sospedra et al., 2010 |
|                                  | Beverages                                      | 33            | Ice coffee (beverage)                                                       | Thailand                  | Chomvarin et al., 2006                 |
|                                  | Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products) | 37            | Other food, beans                                                           | India, Malawi             | Roy et al., 2007; Taulo et al., 2008    |
| **Yersinia enterocolitica**      | Seeds for sprouting and sprouted seeds         | 28            | Soybean sprout                                                              | Korea                     | Lee et al., 2004                       |
| **Parasites**                    |                                               |               |                                                                              |                           |                                       |
| Cryptosporidium spp.             | Seeds for sprouting and sprouted seeds         | 28            | Mung bean, mung bean sprouts                                               | Norway, Canada            | Robertson et al., 2002; Robertson et al., 2005 |
| **Enterocytozoon bieneusi**      | Seeds for sprouting and sprouted seeds         | 28            | Mung bean sprouts                                                           | Poland, USA               | Jedrzejewski et al., 2007              |
| Giardia spp.                     | Seeds for sprouting and sprouted seeds         | 28            | Radish, mung bean, mung bean sprouts                                       | Norway, Canada            | Robertson et al., 2002; Robertson et al., 2005 |
| Microsporidian spores            | Seeds for sprouting and sprouted seeds         | 28            | Sprouts                                                                     | Poland, USA               | Jedrzejewski et al., 2007              |
Table 13: Prevalence of pathogenic bacteria and parasites in association with FoNAO of low water content, EU countries. Pathogens are listed in alphabetical order. “Country” signifies the place where the food commodity was found in association with the biological contaminant (e.g. site of survey or screening).

| Pathogen                  | FoNAO category | Food item         | Source\(^a\)        | Processing/Comment\(^a\) | Prevalence | Country          | Reference(s)          |
|---------------------------|----------------|-------------------|----------------------|--------------------------|------------|------------------|------------------------|
| **Pathogenic bacteria**   |                |                   |                      |                          |            |                  |                        |
| *Bacillus cereus*         | 25             | Rice              | Catering            | processed                | 16/40 (40%)| Italy            | Bonerba et al., 2010   |
|                           | 25             | Rice              | Restaurants         | processed                | 10/54 (19%)| Belgium          | Delbrassinne et al, 2012|
|                           | 32             | Spices            | Restaurants         | heat-treated; dried      | 26/158 (16%)| United Kingdom   | Little et al., 2003    |
|                           | 32             | Spices            | Restaurants         | heat-treated; dried      | 57/237 (24%)| United Kingdom   | Little et al., 2003    |
|                           | 32             | Saffron           | Local retail        | Imported and non-imported| 2/79 (3%)  | Spain            | Cosano et al., 2009    |
|                           | 32             | Herbs             | Local retail        | heat-treated; dried      | 2/743 (0.3%)| United Kingdom   | Sagoo et al., 2009     |
|                           | 32             | Herbs             | Manufacturer        | heat-treated; dried      | 2/23 (9%)  | United Kingdom   | Sagoo et al., 2009     |
|                           | 32             | Spices            | Local retail        | heat-treated; dried      | 18/2090 (1%)| United Kingdom   | Sagoo et al., 2009     |
|                           | 32             | Spices            | Local retail        | heat-treated; dried      | 5/109 (5%) | United Kingdom   | Sagoo et al., 2009     |
|                           | 37             | Ready to eat food | Restaurants         | n.s., spices added       | 130/1936 (7%)| United Kingdom   | Little et al., 2003    |
| **Bacillus cereus** like organism | 25             | Rice              | Local retail        | heat treated; ready to eat | 26/1070 (2%)| Denmark          | Rosenquist et al., 2005|
|                           | 26             | Pasta             | Local retail        | heat treated; ready to eat | 29/2216 (1%)| Denmark          | Rosenquist et al., 2005|
| **Bacillus cereus** spp. group | 25             | Basmati rice      | n.s.                | unprocessed              | 80/80 (100%)| Belgium          | Samapundo et al., 2011 |
|                           | 26             | Pasta             | n.s.                | heat-treated; cooked     | 16/80 (20%)| Belgium          | Samapundo et al., 2011 |
| **Clostridium botulinum** | 37             | Aroma, sauce and gravy | Manufacturer  | processed; refrigerated | 1/62 (2%)  | France           | Carlin et al., 2004    |
|                           | 37             | Thickening agents | Manufacturer        | processed; refrigerated  | 4/25 (16%) | France           | Carlin et al., 2004    |
| **Clostridium perfringens** | 32             | Herbs             | Local retail        | heat-treated; dried      | 5/743 (1%) | United Kingdom   | Sagoo et al., 2009     |
|                           | 32             | Spices            | Local retail        | heat-treated; dried      | 5/2090 (0.2%)| United Kingdom   | Sagoo et al., 2009     |
|                           | 32             | Saffron           | Local retail        | Imported and non-imported| 25/79 (32%)| Spain            | Cosano et al., 2009    |

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| Pathogen                  | FoNAO category | Food item     | Sourcea        | Processing/Commenta | Prevalence       | Country  | Reference(s)          |
|---------------------------|----------------|---------------|----------------|---------------------|------------------|----------|-----------------------|
| **Cronobacter dublinensis** | 32             | Saffron       | Local retail   | Imported and non-imported | 1/79 (0.01%)    | Spain    | Cosano et al., 2009  |
| **Cronobacter malonaticus** | 32             | Pimiento      | Supermarket    | processed           | 2/10 (20%)       | Czech Republic | Hochel et al., 2012 |
| **Cronobacter malonaticus/Cronobacter dublinensis** | 37             | Instant soups | n.s.           | heat-treated        | 1/13 (15%)       | Slovakia | Turcovský et al., 2011 |
| **Cronobacter sakazakii**  | 27             | Bakery products | n.s.          | n.s.                | 1/3 (33%)        | Germany  | ECDC, 2010             |
| **Cronobacter sakazakii**  | 27             | Coconut biscuits | Supermarket  | processed           | 1/1 (100%)       | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii**  | 27             | Oat flakes    | Supermarket    | processed           | 1/10 (10%)       | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii**  | 28             | Poppy seed    | Supermarket    | processed           | 1/11 (9%)        | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii**  | 28             | Wheat sprout  | Supermarket    | processed           | 1/9 (11%)        | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii**  | 31             | Nuts          | n.s.           | n.s.                | 2/2 (100%)       | Slovakia  | Turcovský et al., 2011|
| **Cronobacter sakazakii**  | 32             | Caraway       | Supermarket    | processed           | 2/15 (13%)       | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii**  | 32             | Herbs and spices | Local Retail | heat-treated; dried | 40/122 (33%)    | United Kingdom | Iversen and Forsythe, 2004 |
| **Cronobacter sakazakii**  | 32             | Pepper        | Supermarket    | processed           | 1/14 (7%)        | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii**  | 33             | Tea           | n.s.           | n.s.                | 3/5 (60%)        | Slovakia  | Turcovský et al., 2011|
| **Cronobacter sakazakii**  | 39             | Dried dietary foods intended for infants below 6 months | n.s.          | n.s.                | 1/34 (3%)        | Germany  | ECDC, 2008             |
| 27/3 1/38 | Dry food ingredients other than herbs and spices (nuts, fruit, grains) | Local Retail | heat-treated; dried | 15/66 (23%) | United Kingdom | Iversen and Forsythe, 2004 |
| **Cronobacter sakazakii/Cronobacter dublinensis** | 32             | Herbs         | Local retail/supermarket | heat-treated; dried | 1/23 (4%) | Spain    | Sospedra et al., 2010 |
| **Cronobacter sakazakii/Cronobacter dublinensis** | 37             | Tofu          | Supermarket    | processed           | 4/11 (36%)       | Czech Republic | Hochel et al., 2012 |
| **Cronobacter sakazakii/Cronobacter dublinensis** | 27             | Pastries      | n.s.           | n.s.                | 5/9 (56%)        | Slovakia  | Turcovský et al., 2011|
| **Cronobacter sakazakii/Cronobacter dublinensis** | 28             | Sesam seed    | Supermarket    | processed           | 8/12 (67%)       | Czech Republic | Hochel et al., 2012 |
| Pathogen | FoNAO category | Food item | Source | Processing/Comment | Prevalence | Country | Reference(s) |
|---------|----------------|-----------|--------|--------------------|-----------|---------|--------------|
| malonicus | 32 Ginger | Supermarket | processed | 3/10 (30%) | Czech Republic | Hochel et al., 2012 |
| | 33 Chocolate products | n.s. | n.s. | 11/37 (30%) | Slovakia | Turcovský et al., 2011 |
| | 37 Instant lentil soup | Supermarket | heat-treated | 6/10 (60%) | Czech Republic | Hochel et al., 2012 |
| Cronobacter sakazakii/Cronobacter malonicus/Crono-bacter dublensis | 27 Rice flour | Supermarket | processed | 6/16 (38%) | Czech Republic | Hochel et al., 2012 |
| Cronobacter sakazakii/Cronobacter malonicus/Cronobacter muytjensii | 32 Spices | n.s. | n.s. | 13/21 (62%) | Slovakia | Turcovský et al., 2011 |
| Cronobacter sakazakii/Cronobacter malonicus/Cronobacter turicensis | 28 Pumpkin seed | Supermarket | processed | 5/11 (45%) | Czech Republic | Hochel et al., 2012 |
| | 32 Basil | Supermarket | processed | 4/10 (40%) | Czech Republic | Hochel et al., 2012 |
| | 32 Majoram | Supermarket | processed | 2/12 (17%) | Czech Republic | Hochel et al., 2012 |
| Cronobacter spp. | 24 Breakfast cereals | Supermarket | processed; organic production | 9/20 (45%) | Ireland | Molloy et al., 2009 |
| | 27 Dried cereals | Manufacturer/loca l retail | heat-treated; dried | 6/123 (5%) | Netherlands | Kandhai et al., 2010 |
| | 28 Sprouts | Manufacturer | ready to eat | 1/27 (4%) | Swiss | Althaus et al., 2012 |
| | 32 Dried spices | Manufacturer/loca l retail | heat-treated; dried | 1/28 (4%) | Netherlands | Kandhai et al., 2010 |
| | 32 Spices and dried herbs | Local retail | processed; ready to eat | 7/26 (30%) | Ireland | Baumgartner et al., 2009 |
| | 28/16/15 Sprouts/fresh herbs/salads | Local retail | processed; ready to eat | 14/23 (61%) | Ireland | Baumgartner et al., 2009 |
| Enterobacter cloacae | 32 Spices | Local retail/supermarket | heat-treated; dried | 2/30 (7%) | Spain | Sospedra et al., 2010 |
| Pathogen          | FoNAO category | Food item                  | Source\(^a\)            | Processing/Comment\(^a\) | Prevalence | Country       | Reference(s)                  |
|-------------------|----------------|----------------------------|--------------------------|--------------------------|------------|--------------|-------------------------------|
| *Enterobacter gergoviae* | 32  | Spices                     | Local retail/supermarket | heat-treated; dried      | 1/30 (3%)  | Spain         | Sospedra et al., 2010         |
| *Listeria monocytogenes* | 27  | Bakery products            | Local retail             | n.s.                     | 2/14 (14%) | Lithuania     | ECDC, 2008                   |
|                   | 27  | Cakes                      | Hotels/restaurants/pastry shops | processed               | 12/283 (4%) | Croatia       | Uhitil et al., 2004           |
|                   | 27  | Cereals and meals          | Local retail             | n.s.                     | 2/214 (1%) | Ireland       | ECDC, 2008                   |
|                   | 27  | Cereals and meals          | Manufacturer             | n.s.                     | 19/333 (6%) | Luxembourg    | ECDC, 2009                   |
|                   | 27  | Confectionery products and pastes | Local retail | n.s.                     | 5/300 (2%) | Slovenia      | ECDC, 2008                   |
|                   | 27  | Confectionery products and pastes | n.s. | n.s.                     | 1/490 (0.2%) | Hungary       | ECDC, 2008                   |
|                   | 27  | Flour                      | Manufacturer/local retail | processed               | 5/27 (19%) | Portugal      | Mena et al., 2004            |
|                   | 27  | Pastries                   | Manufacturer/local retail | processed               | 3/73 (4%)  | Portugal      | Mena et al., 2004            |
|                   | 28  | Seeds                      | n.s.                     | sprouted; ready to eat   | 1/88 (1%)  | Hungary       | ECDC, 2009                   |
|                   | 32  | Spices and herbs           | n.s.                     | n.s.                     | 1/2 (50%)  | Italy         | ECDC, 2008                   |
| 31/3              | 8   | Dried fruits (walnut, hazelnut, pine-nut, sultana, apricot) | Manufacturer/local retail | processed               | 1/12 (8%)  | Portugal      | Mena et al., 2004            |
| *Salmonella Bredeney* | 32  | Spices and herbs           | n.s.                     | n.s.                     | 3/45 (7%)  | Slovakia      | ECDC, 2008                   |
| *Salmonella Enteritidis* | 27  | Bakery products            | Local retail             | n.s.                     | 10/35 (29%) | Lithuania     | ECDC, 2008                   |
|                   | 27  | Bakery products (cakes)    | n.s.                     | n.s.                     | 29/6339 (0.5%) | Spain        | ECDC, 2008                   |
|                   | 27  | Confectionery products and pastes | n.s. | n.s.                     | 1/39 (3%)  | Slovakia      | ECDC, 2008                   |
|                   | 27  | Confectionery products and pastes | n.s. | n.s.                     | 1/209 (0.5%) | Hungary       | ECDC, 2008                   |
|                   | 27  | Noodles                    | n.s.                     | n.s.                     | 9/36 (25%) | Slovakia      | ECDC, 2008                   |
|                   | 27  | Noodles                    | n.s.                     | n.s.                     | 3/288 (1%) | Slovakia      | ECDC, 2008                   |
|                   | 27  | Noodles                    | n.s.                     | n.s.                     | 5/292 (2%) | Hungary       | ECDC, 2008                   |
| Pathogen                  | FoNAO category | Food item            | Source*  | Processing/Comment* | Prevalence          | Country          | Reference(s) |
|--------------------------|----------------|----------------------|----------|--------------------|---------------------|------------------|---------------|
| *Salmonella Infantis*    | 32             | Spices and herbs     | Local retail | n.s.               | 1/1768 (0.1%)       | Netherlands      | ECDC, 2008    |
| *Salmonella spp.*        | 33             | Chocolate            | n.s.     | n.s.               | 1/145 (1%)          | Hungary          | ECDC, 2008    |
|                          | 27             | Bakery products      | n.s.     | n.s.               | 3/1354 (0.2%)       | Spain            | ECDC, 2009    |
|                          | 27             | Cereals and meals    | Manufacturer | heat-treated; cooked | 3/485 (0.6%)       | Luxembourg      | ECDC, 2009    |
|                          | 27             | Noodles              | Local retail | n.s.               | 1/2320 (0.05%)     | Ireland          | ECDC, 2009    |
|                          | 27             | Noodles              | Manufacturer | n.s.               | 9/19363 (0.05%)    | Ireland          | ECDC, 2009    |
|                          | 27             | Noodles              | Manufacturer | n.s.               | 1/27 (4%)          | Slovakia         | ECDC, 2009    |
|                          | 27             | Alfalfa seeds        | Local retail | ready to eat | 1/58 (2%)          | United Kingdom + Import | Willis et al., 2009 |
|                          | 27             | Linseed (flax)       | Local retail | ready to eat | 1/284 (0.4%)       | United Kingdom + Import | Willis et al., 2009 |
|                          | 27             | Melon (egusi)        | Local retail | ready to eat | 4/47 (9%)         | United Kingdom + Import | Willis et al., 2009 |
|                          | 27             | Sesame               | Local retail | ready to eat | 13/771 (2%)       | United Kingdom + Import | Willis et al., 2009 |
|                          | 27             | Seeds                | Manufacturer | heat-treated; dried | 1/1 (100%)       | Romania          | ECDC, 2009    |
|                          | 27             | Seeds                | n.s.     | sprouted; ready to eat | 1/174 (0.6%)    | Netherlands      | ECDC, 2009    |
|                          | 27             | Seeds mixed          | Local retail | ready to eat | 3/350 (1%)       | United Kingdom + Import | Willis et al., 2009 |
|                          | 28             | Seeds, sprouted      | n.s.     | unprocessed        | 1/229 (5%)         | Germany          | ECDC, 2008    |
|                          | 28             | Sesam seed           | n.s.     | processed          | 11/117 (9%)        | Germany          | Brockmann et al., 2004 |
|                          | 28             | Sesam seed           | n.s.     | processed          | 2/16 (13%)        | Germany          | Brockmann et al., 2004 |
|                          | 28             | Sunflower            | Local retail | ready to eat | 1/979 (0.1%)      | United Kingdom + Import | Willis et al., 2009 |
|                          | 31             | Brazil nut           | Local retail | processed         | 2/469 (0.4%)      | United Kingdom | Little et al., 2010 |
|                          | 31             | Mixed nuts           | Local retail | processed         | 1/105 (1%)        | United Kingdom | Little et al., 2010 |
|                          | 31             | Nuts                 | Local retail | heat-treated; roasted; ready to eat | 1/727 (0.1%) | United Kingdom | Little et al., 2009 |
| Pathogen                | FoNAO category | Food item              | Source* | Processing/Comment* | Prevalence | Country       | Reference(s)                  |
|------------------------|----------------|------------------------|---------|---------------------|------------|---------------|------------------------------|
| Food of plant origin with low water content | 31 Pistachios   | Local retail           | heat-treated; roasted; ready to eat | 1/25 (4%) | United Kingdom | Little et al., 2009          |
|                        | 32 Curry        | Local retail           | n.s.    |                     | 1/412 (0.2%) | Netherlands    | ECDC, 2009                   |
|                        | 32 Spices       | Local retail           | heat-treated; dried           | 63/1857 (3%) | Netherlands    | ECDC, 2009                   |
|                        | 32 Spices       | Restaurants            | heat-treated; dried           | 1/154 (1%) | United Kingdom | Little et al., 2003           |
|                        | 32 Spices and herbs | Local retail       | heat-treated; dried           | 2/198 (1%) | Hungary       | ECDC, 2008                   |
|                        | 32 Spices and herbs | Local retail       | Imported                          | 1/238 (0.4%) | United Kingdom | ECDC, 2009                   |
|                        | 32 Spices and herbs | Local retail       | n.s.                              | 67/1768 (4%) | Netherlands    | ECDC, 2008                   |
|                        | 32 Spices       | Local retail           | n.s.                              | 1/41 (2%)  | Sweden        | ECDC, 2009                   |
|                        | 32 Spices and herbs | Local retail       | n.s.                              | 1/243 (0.4%) | Hungary       | ECDC, 2009                   |
|                        | 32 Herbs        | Local retail           | heat-treated; dried           | 10/743 (1%) | United Kingdom | Sagoo et al., 2009           |
|                        | 32 Spices       | Local retail           | heat-treated; dried           | 21/2090 (1%) | United Kingdom | Sagoo et al., 2009           |
|                        | 37 Halvah       | n.s.                  | processed                         | 8/71 (11%) | Germany       | Brockmann et al., 2004       |
|                        | 37 Sesam paste  | n.s.                  | processed                         | 1/12 (8%)  | Germany       | Brockmann et al., 2004       |
| Salmonella Typhimurium  | 32 Spices and herbs | Local retail       | n.s.                              | 1/1768 (0.1%) | Netherlands    | ECDC, 2008                   |
| Shigella sonnei         | 32 Herbs        | Local retail/supermarket | heat-treated; dried           | 1/23 (4%)  | Spain         | Sospedra et al., 2010        |
| Shigella spp.           | 32 Herbs        | Local retail/supermarket | heat-treated; dried           | 2/23 (9%)  | Spain         | Sospedra et al., 2010        |
|                        | 32 Spices       | Local retail/supermarket | heat-treated; dried           | 3/30 (10%) | Spain         | Sospedra et al., 2010        |
| Staphylococcal enterotoxins | 27 Cereals and meals | Local retail       | n.s.                              | 20/728 (3%) | Luxembourg    | ECDC, 2009                   |
|                        | 27 Cereals and meals | Local retail       | n.s.                              | 1/1 (100%) | Ireland       | ECDC, 2009                   |
|                        | 27 Confectionery products and pastes | Manufacturer | n.s.                              | 2/6 (33%)  | Slovakia      | ECDC, 2009                   |
|                        | 33 Chocolate    | Manufacturer           | n.s.                              | 4/28 (14%) | Luxembourg    | ECDC, 2009                   |
| Staphylococcus aureus   | 32 Herbs        | Local retail/supermarket | heat-treated; dried           | 1/23 (4%)  | Spain         | Sospedra et al., 2010        |
|                        | 32 Spices       | Local retail/supermarket | heat-treated; dried           | 2/30 (7%)  | Spain         | Sospedra et al., 2010        |

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## Table 14: Prevalence of pathogenic bacteria and parasites in association with FoNAO of low water content, non-EU countries and EU plus non-EU countries. Pathogens are listed in alphabetical order. “Country” signifies the place where the food commodity was found in association with the biological contaminant (e.g. site of survey or screening).

| Pathogen          | FoNAO category | Food item                | Sourcea | Processing/Commenta | Prevalence | Country  | Reference(s)                  |
|-------------------|----------------|--------------------------|---------|---------------------|------------|----------|-------------------------------|
| *Cryptosporidium* | 28             | Mung bean                | Manufacturer | n.s.                | 14/149 (9%) | Norway   | Robertson et al., 2002       |
| *Giardia*         | 28             | Mung bean                | Manufacturer | n.s.                | 3/149 (2%)  | Norway   | Robertson et al., 2002       |
|                   | 28             | Radish                   | Manufacturer | n.s.                | 1/6 (17%)   | Norway   | Robertson et al., 2002       |
| a n.s.= not specified |

Pathogen          | FoNAO category | Food item                | Sourcea | Processing/Commenta | Prevalence | Country  | Reference(s)                  |
|-------------------|----------------|--------------------------|---------|---------------------|------------|----------|-------------------------------|
| *Bacillus cereus* | 24             | Barley                   | n.s.    | unprocessed         | 16/76 (21%) | Korea    | Park et al., 2008             |
|                   | 24             | Cereal                   | n.s.    | unprocessed         | 73/293 (25%) | Korea    | Park et al., 2008             |
|                   | 24             | Job’s tears (*Coix lacryma jobi*) | n.s.    | unprocessed         | 19/71 (27%) | Korea    | Park et al., 2008             |
|                   | 24             | Wheat                    | Manufacturer | processed         | 41/58 (70%) | Australia | Berghofer et al., 2003       |
|                   | 24             | Wheat                    | Manufacturer | unprocessed        | 47/58 (81%) | Australia | Berghofer et al., 2003       |
|                   | 24             | Wheat                    | n.s.    | unprocessed         | 5/27 (19%)  | Turkey    | Alp et al., 2008              |
|                   | 24             | Wheat flour              | n.s.    | processed           | 1/8 (13%)   | Turkey    | Segun et al., 2012           |
|                   | 24             | Wheat flour              | n.s.    | unprocessed         | 3/20 (15%)  | Argentina | Fangio et al., 2010          |
|                   | 24             | Wheat grain              | Manufacturer | unprocessed        | 2/50 (4%)   | Australia | Eglezos 2010a                 |
|                   | 25             | Brown rice               | n.s.    | unprocessed         | 15/83 (18%) | Korea    | Park et al., 2008             |
|                   | 25             | Fried rice with vegetable/Chinese-Style | Restaurants | processed         | 36/200 (18%) | Sri Lanka | Perera and Ranasinghe 2012    |
|                   | 25             | Glutinous rice           | n.s.    | unprocessed         | 23/63 (37%) | Korea    | Park et al., 2008             |
| Pathogen | FoNAO category | Food item | Source | Processing stage/Comment | Prevalence | Country | Reference(s) |
|----------|----------------|-----------|--------|--------------------------|------------|---------|--------------|
| 25       |                | Rice      | Restaurants | heat-treated            | 1/26 (4%)  | Nigeria | Isara et al., 2010 |
| 25       |                | Rice      | Restaurants | heat-treated; fried      | 8/26 (31%) | Nigeria | Isara et al., 2010 |
| 25       |                | Rice (brown, white, wild type, black and rice mixtures) | Local retail/supermarket | non-par boiled | 83/178 (47%) | USA | Ankolekar et al., 2009 |
| 27       |                | Breakfast cereals | Supermarket | processed | 25/41 (61%) | Malaysia | Lee et al., 2009 |
| 27       |                | Breakfast cereals | Supermarket | processed | 8/8 (100%) | Malaysia | Lee et al., 2009 |
| 27       |                | Cereal products | Supermarket | processed | 87/111 (78%) | Malaysia | Lee et al., 2009 |
| 27       |                | Pre-mixed drinks | Supermarket | processed | 14/15 (93%) | Malaysia | Lee et al., 2009 |
| 27       |                | Raw cereals | Supermarket | n.s. | 15/17 (88.9%) | Malaysia | Lee et al., 2009 |
| 27       |                | Biscuits (Infant food) | Local retail/online market | heat-treated | 4/10 (40%) | Korea | Kim et al., 2011a |
| 27       |                | Bran | Manufacturer | processed | 51/54 (94%) | Australia | Berghofer et al., 2003 |
| 27       |                | Flour | Manufacturer | processed | 66/71 (93%) | Australia | Berghofer et al., 2003 |
| 27       |                | Wheat germ | Manufacturer | processed | 28/43 (64%) | Australia | Berghofer et al., 2003 |
| 27       |                | Raw cereals | Supermarket | n.s. | 15/17 (88.9%) | Malaysia | Lee et al., 2009 |
| 27       |                | Sprouts (Phaseolus vulgaris) | Investigation institute | unprocessed | n.d. | Venezuela | Cava et al., 2009 |
| 32       |                | Dried red pepper | Local retail | heat-treated; dried | 118/140 (84%) | Korea | Choo et al., 2007 |
| 32       |                | Red pepper powder | Manufacturer | processed | 42/112 (38%) | Korea | Oh et al., 2012 |
| 32       |                | Spices | Local retail | heat-treated; dried | 83/154 (54%) | India | Banerjee et al., 2003 |
| 33       |                | Ground roasted coffee beans | n.s. | n.s. | 17/30 (57%) | Brazil | Chaves et al., 2012 |
| 37       |                | Other food | Local retail | processed; fermented | 21/105 (20%) | India | Roy et al., 2007 |
| 37       |                | Rice soup (Infant food) | Local retail/online market | heat-treated | 7/34 (21%) | Korea | Kim et al., 2011a |
## Food of plant origin with low water content

### Pathogen

| Pathogen               | FoNAO category | Food item              | Source\(^a\)                | Processing stage/Comment\(^a\) | Prevalence | Country   | Reference(s)     |
|------------------------|----------------|------------------------|------------------------------|--------------------------------|------------|-----------|------------------|
| Campylobacter coli     | 28             | Mung bean sprout       | Local retail/supermarket     | unprocessed                    | 17/41 (41%)| Malaysia  | Chai et al., 2007|
| Campylobacter jejuni   | 27             | Vhuswa                 | Home-made                    | processed                       | 2/125 (2%) | South Africa | Potgieter et al., 2005|
|                        | 28             | Mung bean sprout       | Local retail/supermarket     | unprocessed                    | 19/41 (46%)| Malaysia  | Chai et al., 2007|
| Clostridium botulinum  | 32             | Chamomile              | Local retail                 | unwrapped samples and tea bags | 15/200 (8%)| Argentina | Bianco et al., 2008|
|                        | 32             | Linden flower (Tilia spp.) | Local retail                 | unwrapped samples              | 3/100 (3%) | Argentina | Bianco et al., 2009|
| Clostridium perfringens| 32             | Spices                 | Local retail                 | heat-treated; dried            | 26/154 (17%)| India     | Banerjee et al., 2003|
|                        | 32             | Spices                 | Local retail/manufacturer     | processed                      | 14/115 (12%)| Argentina | Aguilera et al., 2005|
|                        | 37             | Tarhana                | Local retail                 | processed                      | 3/8 (38%)  | Turkey    | Segun et al., 2012|
| Cronobacter dublinensis| 27             | Flour                  | Local retail                 | processed                      | 1/3 (33%)  | Jordan    | Shaker et al., 2007|
|                        | 27             | Semolina               | Local retail                 | processed                      | 1/3 (33%)  | Jordan    | Shaker et al., 2007|
|                        | 27             | Starch                 | Local retail                 | processed                      | 1/3 (33%)  | Jordan    | Shaker et al., 2007|
| Cronobacter maytjensii | 27             | Sunsik                 | Local retail/supermarket     | processed                      | 6/86 (7%)  | Korea     | Lee et al., 2012|
| Cronobacter sakazakii  | 27             | Sunsik                 | Local retail/supermarket     | processed                      | 2/86 (2%)  | Korea     | Lee et al., 2012|
|                        | 27             | Cereal products        | Local retail/supermarket     | n.s.                           | 8/50 (16%) | Korea     | Lee et al., 2012|
|                        | 27             | Dried adults cereals   | Supermarket/manufacturer     | processed                      | 2/8 (25%)  | USA       | Restaino et al., 2006|
|                        | 27             | Dried flour or meals (Corn, soy, wheat and rice) | Supermarket/manufacturer | processed                      | 14/87 (18%)| USA       | Restaino et al., 2006|

\(^a\) Food item in the source table is given as reported.
| Pathogen | FoNAO category | Food item | Source\(^a\) | Processing stage/Comment\(^a\) | Prevalence | Country | Reference(s) |
|----------|----------------|-----------|--------------|-------------------------------|------------|---------|--------------|
| Cronobacter spp. | 24 | Grains | Local retail | unprocessed | 7/39 (18%) | Korea | Chon et al., 2012 |
| 27 | Grains and beans | Local retail | unprocessed | 6/20 (30%) | Korea | Kim et al., 2011b |
| 27 | Sunsik | Local retail/supermarket | processed | 31/86 (36%) | Korea | Lee et al., 2012 |
| 32 | Anise | Local retail | n.s. | 4/8 (50%) | Jordan | Jaradat et al., 2009 |
| 32 | Chamomile | Local retail | n.s. | 2/8 (25%) | Jordan | Jaradat et al., 2009 |
| 32 | Fennel | Local retail | n.s. | 3/6 (50%) | Jordan | Jaradat et al., 2009 |
| 32 | Herbs and spices | Local retail | n.s. | 26/67 (39%) | Jordan | Jaradat et al., 2009 |
| 32 | Herbs and spices | Local retail | unprocessed | 5/26 (19%) | Korea | Chon et al., 2012 |
| 32 | Liquorice | Local retail | n.s. | 4/4 (100%) | Jordan | Jaradat et al., 2009 |
| 32 | Mixed Spices | Local retail | n.s. | 11/15 (73%) | Jordan | Jaradat et al., 2009 |
| 32 | Sage | Local retail | n.s. | 1/2 (50%) | Jordan | Jaradat et al., 2009 |

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| Pathogen                        | FoNAO category | Food item     | Sourcea          | Processing stage/Commenta | Prevalence | Country | Reference(s)                        |
|--------------------------------|----------------|---------------|------------------|---------------------------|------------|---------|-------------------------------------|
| `Thyme`                        | 32             | Local retail  | n.s.             |                           | 1/4 (25%)  | Jordan  | Jaradat et al., 2009               |
| `Escherichia coli 0157:H7 (EHEC)` | 37             | Beans         | Home-made        | heat-treated; cooked      | 2/13 (15%) | Malawi  | Taulo et al., 2008                |
| `Klebsiella pneumonia`         | 31             | Almond        | Local retail     | processed; fruit juice    | 3/7 (43%)  | Libya   | Ghenghesh et al., 2005            |
|                                | 33             | Tamarind      | Local retail     | heat treated; dried; pulp tea infusion | 1/44 (2%)  | Jordan  | Nassereddin and Yamani, 2005       |
| `Listeria monocytogenes`       | 27             | Hosmerim dessert | Local retail | n.s.                    | 3/100 (3%) | Turkey  | Cokal et al., 2012                |
|                                | 28             | Alfalfa sprouts | Supermarket | polyethylene packaging container | 1/6 (17%)  | Korea   | Waje et al., 2009                 |
|                                | 28             | Broccoli sprouts | Supermarket | polyethylene packaging container | 1/7 (14%)  | Korea   | Waje et al., 2009                 |
|                                | 28             | Red radish sprouts | Supermarket | polyethylene packaging container | 1/6 (17%)  | Korea   | Waje et al., 2009                 |
|                                | 28             | Sprouts       | Supermarket     | polyethylene packaging container | 3/55 (5%)  | Korea   | Waje et al., 2009                 |
|                                | 31             | Mixed nuts    | Manufacturer    | heat-treated; cooked; ready-to-eat; packed | 2/564 (0.4%) | Australia | Eglezos 2010b                      |
|                                | 31             | Mixed nuts    | Manufacturer    | heat-treated; cooked; ready-to-eat; packed | 2/43 (5%)  | Australia | Eglezos 2010b                      |
| `Pseudomonas aeruginosa`       | 25             | Rice          | Restaurants     | heat-treated; fried       | 1/3 (33%)  | Nigeria  | Isara et al., 2010                |
|                                | 31             | Almond        | Local retail    | processed; fruit juice    | 1/7 (14%)  | Libya    | Ghenghesh et al., 2005            |
|                                | 33             | Sous          | Local retail    | heat treated; dried; pulp tea infusion | 1/21 (5%)  | Jordan  | Nassereddin and Yamani, 2005       |
| `Salmonella Agona`             | 32             | Ground red pepper | Local retail | unprocessed               | 1/25 (4%)  | Turkey   | Erol et al., 2009                 |
| `Salmonella Bredeney`          | 32             | Black pepper powder | Local retail | processed; powder        | 1/25 (4%)  | Turkey   | Erol et al., 2009                 |
| `Salmonella Enterica`          | 32             | Black pepper  | Local retail    | processed                | 1/42 (2%)  | Japan    | Hara-Kudo et al., 2006            |

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| Pathogen               | FoNAO category | Food item       | Source\(^a\)  | Processing stage/Comment\(^a\) | Prevalence | Country | Reference(s) |
|------------------------|----------------|-----------------|---------------|-------------------------------|------------|---------|--------------|
| *Salmonella Enteritidis* | 31             | Almond          | Manufacturer  | unprocessed                   | 5/4153 (0.1%) | USA     | Bansal et al., 2010 |
| *Salmonella Kentucky*   | 32             | Red pepper powder | Local retail  | processed; powder              | 1/25 (4%)   | Turkey  | Erol et al., 2009  |
| *Salmonella Muenchen*   | 31             | Almond          | Manufacturer  | unprocessed                   | 8/4153 (0.2%) | USA     | Bansal et al., 2010 |
| *Salmonella Newport*    | 31             | Almond          | Manufacturer  | unprocessed                   | 6/4153 (0.1%) | USA     | Bansal et al., 2010 |
| *Salmonella* spp.      | 24             | Maize; porridge | Home-made     | processed                     | 5/15 (35%)  | Kenya   | Muoki et al., 2008 |
|                        | 24             | Maize; ugali    | Home-made     | processed                     | 3/15 (20%)  | Kenya   | Muoki et al., 2008 |
|                        | 24             | Wheat grain     | Manufacturer  | unprocessed                   | 1/50 (2%)   | Australia | Eglezos 2010a |
|                        | 24             | Wheat grass     | Take-away     | processed; juice              | 2/3 (67%)   | India   | Titarmare et al., 2009 |
|                        | 27             | Maize flour porridge | Home-made     | heat-treated; cooked          | 9/41 (22%)  | Malawi  | Taulo et al., 2008 |
|                        | 27             | Mandazi; chapati | Home-made     | processed                     | 3/15 (17%)  | Kenya   | Muoki et al., 2008 |
|                        | 27             | Vhuswa          | Home-made     | processed                     | 6/125 (5%)  | South Africa | Potgieter et al., 2005 |
|                        | 31             | Almond          | Manufacturer  | n.s.                          | 137/13972 (1%) | USA     | Lambertini et al., 2012 |
|                        | 31             | Almond          | Manufacturer  | unprocessed                   | 81/9274 (1%) | USA     | Danyluk et al., 2007 |
|                        | 31             | Almond          | Manufacturer  | unprocessed                   | 42/50 (84%) | USA     | Danyluk et al., 2006 |
|                        | 31             | Almond kernel   | Manufacturer  | unprocessed                   | 46/3698 (1%) | USA     | Bansal et al., 2010 |
|                        | 31             | Inshell almond  | Manufacturer  | unprocessed                   | 7/455 (2%)  | USA     | Bansal et al., 2010 |
|                        | 31             | Nuts            | Manufacturer  | prior to roasting             | 1/921 (0.11%) | Australia | Eglezos et al., 2008 |
|                        | 31             | Raw almond      | Manufacturer  | prior to roasting             | 1/60 (2%)   | Australia | Eglezos et al., 2008 |
|                        | 32             | Black pepper    | Supermarket   | heat-treated; dried           | 12/66 (18%) | Brazil  | Moreira et al., 2009 |
|                        | 32             | Cumin           | Supermarket   | heat-treated; dried           | 1/15 (7%)   | Brazil  | Moreira et al., 2009 |
|                        | 33             | Sous            | Local retail   | heat treated; dried; roots of glyrrhiza glabra tea infusion | 1/21 (5%) | Jordan  | Nassereddin and Yamani, 2005 |

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| Pathogen                          | FoNAO category | Food item          | Source | Processing stage/Comment | Prevalence | Country | Reference(s)                  |
|----------------------------------|----------------|--------------------|--------|--------------------------|------------|---------|-------------------------------|
| **Salmonella spp.**              |                |                    |        |                          |            |         |                               |
| (unsatisfactory according to EC2004) |                |                    |        |                          |            |         |                               |
| **Salmonella Typhi**             | 25             | Rice               | Restaurants | heat-treated           | 1/3 (33%)  | Nigeria | Isara et al., 2010            |
| **Salmonella Typhimurium**       | 31             | Almond             | Manufacturer | unprocessed          | 4/4153 (0.1%) | USA     | Bansal et al., 2010           |
| **Shigella sonnei**              | 25             | Rice               | Restaurants | heat-treated; fried | 1/3 (33%)  | Nigeria | Isara et al., 2010            |
| **Shigella spp.**                | 27             | Vhuswa             | Home-made | processed               | 6/125 (5%) | South Africa | Potgieter et al., 2005 |
| **Staphylococcus aureus**        | 24             | Wheat              | n.s.    | unprocessed             | 6/27 (22%) | Turkey   | Alp et al., 2008             |
| **Kimbab; korean snack**         | 25             | Kimbab             | Retail Distribution | processed; ready to eat | 39/494 (8%) | Korea | Oh et al., 2007              |
| **Nem chao**                     | 25             | Nem chao           | Local retail | ready to eat         | 4/28 (14%) | Japan, Vietnam, Bagladesch | Huong et al.2010 |
| **Rice cake**                    | 25             | Rice cake          | Local retail | ready to eat         | 9/55 (16%) | Japan, Vietnam, Bagladesch | Huong et al.2010 |
| **Rice cakes with filling**      | 25             | Rice cakes with filling | Retail Distribution | processed; ready to eat | 17/88 (19%) | Korea | Oh et al., 2007              |
| **Rice cakes without filling**   | 25             | Rice cakes without filling | Retail Distribution | processed; ready to eat | 37/254 (15%) | Korea | Oh et al., 2007              |
| **Sticky rice**                  | 25             | Sticky rice        | Local retail | ready to eat         | 1/8 (13%)  | Japan, Vietnam, Bagladesch | Huong et al.2010 |
| **Bread**                        | 27             | Bread              | Retail Distribution | processed; ready to eat | 4/88 (5%)  | Korea | Oh et al., 2007              |
| **Buckwheat vermicelli**         | 27             | Buckwheat vermicelli | Retail Distribution | processed; ready to eat | 41/223 (18%) | Korea | Oh et al., 2007             |
| **Cream-bread**                  | 27             | Cream-bread        | Retail Distribution | processed; ready to eat | 7/124 (6%) | Korea | Oh et al., 2007              |
| **Cream-cake**                   | 27             | Cream-cake         | Retail Distribution | processed; ready to eat | 12/38 (32%) | Korea | Oh et al., 2007              |
| **Hosmerim dessert**             | 27             | Hosmerim dessert   | Local retail | n.s.                  | 64/100 (64%) | Turkey | Cokal et al., 2012           |
### Pathogen

| Pathogen               | FoNAO category | Food item          | Source<sup>a</sup> | Processing stage/Comment<sup>a</sup> | Prevalence | Country          | Reference(s)                |
|------------------------|----------------|--------------------|---------------------|--------------------------------------|------------|------------------|-----------------------------|
| Yersinia enterocolitica| 28             | Soybean sprouts    | Supermarket         | ready to eat                         | 3/87 (3%)  | Korea            | Lee et al., 2004            |
| *Cryptosporidium* spp. | 28             | Mung bean sprouts  | n.s.                | n.s.                                 | 14/149 (9%)| Norway, Canada   | Robertson et al., 2005      |
| *Enterocytozoon* bieneusi | 28         | Mung bean sprouts  | Manufacturer        | n.s.                                 | 1/5 (20%)  | Poland           | Jedrzejewski et al., 2007   |
| *Giardia* spp.         | 28             | Mung bean sprouts  | n.s.                | n.s.                                 | 3/149 (2%) | Norway, Canada   | Robertson et al., 2005      |
| Microsporidian spores  | 28             | Sprouts            | Manufacturer        | n.s.                                 | 1/20 (5%)  | Poland           | Jedrzejewski et al., 2007   |

<sup>a</sup>n.s. = not specified

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Table 15: Growth, survival or reduction of pathogenic bacteria, viruses and parasites linked to FoNAO with low water content.

| Pathogen                  | Food item                  | FoNAO category | Trial conditions/treatment                                                                 | Treatment time | Increase/ decrease | Reference(s)                        |
|---------------------------|----------------------------|----------------|--------------------------------------------------------------------------------------------|----------------|---------------------|--------------------------------------|
| *Aeromonas hydrophila*    | Rice pudding               | 25             | 4°C; Seeds inoculated during soaking (steeping medium 6.5 log cfu/mL), followed by germination, autoclaving, and sun drying; B. cereus counts on raw materials, after steeping, and after 24 h and 48 h of germination | 22 days        | Maximum population: 8.00-9.23 log cfu/g | Papageorgiou et al., 2003            |
| *Bacillus cereus*         | Finger millet              | 24             | 25°C; initial pH 4.6-4.7; MAP(5%, CO2, app. 80%) | 24 weeks       | -0.2 log cfu/g      | Kimura et al., 2008                  |
|  | Kidney beans              | 27             | 30°C; initial pH 4.6-4.7; MAP(5%, CO2, app. 80%) | 2 weeks        | +4.7 log cfu/g      | Kimura et al., 2008                  |
| *Clostridium botulinum*   | Rice/steamed               | 25             | 30°C; aseptically packed under MAP (0% O2, app. 5% CO2, app. 80% N2) | 12 weeks       | app. +4.4 log cfu/g | Kasai et al., 2005                   |
|  | Rice/steamed products     | 25             | 30°C; initial pH 4.6-4.7; MAP(5%, CO2, 95% N2); deoxidant pack for an O2- concentration of 0.3% | 24 weeks       | -0.2 log cfu/g      | Kimura et al., 2008                  |
|  | Rice/steamed products     | 25             | 30°C; initial pH 4.6-4.7; MAP(5%, CO2, 95% N2); deoxidant pack for an O2- concentration of 0.3% | 2 weeks        | +4.7 log cfu/g      | Kimura et al., 2008                  |
| *Cronobacter muytjensii*  | wheat                      | 24             | 25 or 37°C; prepared with grape or apple juices | 24 hrs         | > 2.3 log cfu/g     | Osaili et al., 2009                  |
| *Cronobacter sakazakii*   | wheat                      | 24             | 25 or 37°C; hydrated with water or milk | 24 hrs         | > 5 log cfu/g       | Osaili et al., 2009                  |
| *Cronobacter spp.*        | Herbal infant teas         | 33             | reconstituting herbal infant tea at 37, 21 or ≥ 60°C | 6 hrs          | 4 log cfu reduction at ≥ 60°C | Al-Nabulsli et al., 2009             |
| *Enterobacter sakazakii*  | Infant cereal/oatmeal/     | 27             | 30°C; low inoculum | 72 hrs         | app. +4 log cfu/ml  | Lin and Beuchat, 2007                |
|  | reconstituted with sterile apple juice |  |  |  |  |  |
|  | Infant cereal/oatmeal/     | 27             | 30°C; high inoculum | 72 hrs         | app. +4.5 log cfu/ml | Lin and Beuchat, 2007                |
|  | reconstituted with sterile apple juice |  |  |  |  |  |
| *Escherichia coli*        | Walnut kernels             | 31             | 23°C | 105 days | -2.6 log cfu/g | Blessington et al., 2012 |
| O157:H7 (EHEC)            | Alfalfa sprouts            | 28             | 20, 30 or 35°C | 2 days | +2.3 log cfu/g | Charkowski et al., 2002 |

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| Pathogen                  | Food item                  | FoNAO category | Trial conditions/treatment                                      | Treatment time | Increase/ decrease                   | Reference(s)                                      |
|--------------------------|----------------------------|----------------|---------------------------------------------------------------|----------------|--------------------------------------|--------------------------------------------------|
|                          |                            |                |                                                               |                |                                     |                                                  |
| Food of plant origin with low water content | Alfalfa sprouts | 28 | 25°C; Air                                                   | 48 hrs         | 5.0 ± 2.5 x 10^7 cfu/g (maximum average) | Howard and Hutcheson, 2003                        |
|                          | Peanut                     | 31 | 4°C                                                        | 15 weeks       | app. -2.8 cfu/g                      | Kilonzo-Nthenge et al., 2009                     |
|                          |                            |                |                                                               |                |                                     |                                                  |
| **Listeria monocytogenes** | Boza/cereal beverage   | 24 | pH 2.6; 0.8% titratable acidity after 72 hrs              | 72 hrs         | -2.9 log cfu/ml                     | Güven and Benlkaya, 2005                         |
|                          | Rice                       | 25 | 4°C                                                        | 6 days         | no growth⁴                           | Cronin and Wilkinson, 2009                       |
|                          | Rice                       | 25 | 10, 18°C                                                   | 6 days         | >1.0 log cfu/g                       | Cronin and Wilkinson, 2009                       |
|                          | Rice                       | 25 | 25°C                                                       | 38 hrs         | app. +0.5 log cfu/g                 | Penna et al., 2002                               |
|                          | Alfalfa sprouts            | 28 | 22°C                                                       | 24 hrs         | app. +10³ cfu/g                     | Palmai and Buchanan, 2002                        |
|                          | Peanut/beverage            | 31 | 22°C                                                       | 24 hrs         | +2.6 log cfu/ml                     | Kenney and Beuchat, 2004                         |
|                          | Walnut kernels             | 31 | 23°C                                                       | 105 days       | -3.35 log cfu/g                     | Blessington et al., 2012                         |
|                          | Coconut/fresh cut          | 31 | 12°C; Air; pH 6.0; low inoculum (10¹⁸ cfu/g)               | 6 days         | +2.6 log cfu/g                      | Sinigaglia et al., 2006                         |
| **Salmonella enterica**  | Bread dough                | 27 | 27°C                                                       | 24 hrs         | app. +2.5 log cfu/g                | Pao et al., 2011                                 |
|                          | Alfalfa sprouts            | 28 | 20, 30 or 35°C                                             | 2 days         | +3.7 log cfu/g                      | Charkowski et al., 2002                         |
|                          | Walnut kernels             | 31 | 23°C                                                       | 105 days       | -2.56 log cfu/g                     | Blessington et al., 2012                         |
| **Salmonella Enteritidis** | Almonds                   | 31 | -20°C                                                      | 550 days       | app. -0.4 log cfu/g                | Uesugi et al., 2006                              |
|                          | Almonds                    | 31 | 4°C                                                        | 550 days       | app. -0.2 log cfu/g                | Uesugi et al., 2006                              |
|                          | Almonds                    | 31 | 23°C                                                       | 551 days       | app. -3.1 log cfu/g                | Uesugi et al., 2006                              |
| **Salmonella spp.**      | Cereal/hydrated with water | 24 | 15°C; cereals hydrated with water or milk                  | 24 hrs         | +3.8 log cfu/ml                    | Abushelaibi et al., 2003                         |
|                          | Cereal/hydrated with water | 24 | 25°C                                                       | 24 hrs         | 7.1–7.9 log cfu/ml                 | Abushelaibi et al., 2003                         |
|                          | Cereal/hydrated with water | 24 | 25°C; cereals hydrated with apple juice                    | 24 hrs         | ± 1.5–2.0 log cfu/ml               | Abushelaibi et al., 2003                         |
|                          | Pecan/in-shell             | 31 | 4, 21, 30 or 37 °C; high moisture                         | 8 days         | -1.19 log cfu/g                    | Beuchat and Mann, 2010                          |
|                          | Pecan/granules             | 31 | 37°C                                                       | 45 hrs         | +6.31 log cfu/g                    | Beuchat and Mann, 2010                          |
| Pathogen                  | Food item               | FoNAO category | Trial conditions/treatment                                                                 | Treatment time | Increase/ decrease | Reference(s)          |
|--------------------------|-------------------------|----------------|--------------------------------------------------------------------------------------------|----------------|--------------------|-----------------------|
| Alfalfa seeds            | 8°C                     | 28             | 9 weeks                                                                                     | -0.72 log cfu/g | Beuchat and Scouten, 2002 |
| Alfalfa seeds            | 21°C                    | 28             | 8 weeks                                                                                     | -1.61 log cfu/g | Beuchat and Scouten, 2002 |
| Alfalfa seeds            | no inoculum; minidrum sprouter; conditions similar to those used commercially | 28             | 4 days of sprouting                                                                         | MPN/g remained constant during entire sprouting period | Fu et al., 2008 |
| Alfalfa seeds            | no inoculum; glass jar; conditions as commonly used at home | 28             | 4 days of sprouting                                                                         | app. +4 log MPN/g | Fu et al., 2008 |
| Alfalfa seeds            | 22°C                    | 28             | 6 days                                                                                      | 10^9 cfu/g     | Liao, 2008         |
| Peanut                   | 4°C                     | 31             | 15 weeks                                                                                     | app. -1 log cfu/g | Kilonzo-Nthenge et al., 2009 |
| Salmonella Stanley       | Alfalfa seeds           | 28             | Inoculation at 3 concentrations (~3, ~30, and ~300 CFU/g), flasks or sprouting chamber      | 72 hrs         | app. +5 log cfu/g independent of inoculum concentration | Liu and Schaffner, 2007 |
| Salmonella Typhimurium   | Peanut                  | 31             | 22°C                                                                                       | 7 weeks        | -0.58 log cfu/week | Nummer et al., 2012  |
| Coconut/fresh cut        | 12°C; MAP; pH 6.0; low inoculum (10^2 cfu/g) | 31             | 10 days                                                                                     | +4.4 log cfu/g | Sinigaglia et al., 2006 |
| Staphylococcus aureus    | Finger millet           | 24             | Seeds inoculated during soaking (steeping medium 7 log cfu/mL), followed by germination, autoclaving, and sundrying; S. aureus counts on raw materials, after steeping, and after 24 h and 48 h of germination | after 24 h      | -0.5 log cfu/ml | Kimanya et al., 2003  |
|                         | Kidney beans            | 27             | after 48 h                                                                                   | -0.6 log cfu/ml | Kimanya et al., 2003 |
|                         |                         |                | after 24 h                                                                                   | +0.7 log cfu/ml | Kimanya et al., 2003 |
|                         |                         |                | after 48 h                                                                                   | +0.5 log cfu/ml | Kimanya et al., 2003 |
| No knead bread dough     | 38°C                    | 27             | 24 hrs                                                                                      | app. +2.5 log cfu/g | Pao et al., 2011 |
| Tahin helva              | 4°C                     | 37             | 9 months                                                                                     | Survival: 1.1 x 10^2 cfu/ml | Sengun et al., 2005  |
| Tahin helva              | 20°C                    | 37             | 9 months                                                                                     | Survival: 3.9 x 10^2 cfu/ml | Sengun et al., 2005  |
| Herbal food supplement   | Room temperature; aerobiosis | 39             | 30 days                                                                                     | not detected^a | Rossi et al., 2010 |

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### Pathogen Food item FoNAO category Trial conditions/treatment Treatment time Increase/ decrease Reference(s)

**Herbal food supplement**

- **Pathogen:** Vibrio cholera
  - **Food item:** Rice/boiled/brown
  - **FoNAO category:** 39
  - **Trial conditions/treatment:** Room temperature; anaerobiosis
  - **Treatment time:** 25 days
  - **Increase/ decrease:** not detected
  - **Reference(s):** Rossi et al., 2010

**Viruses**

- **Pathogen:** Hepatitis A
  - **Food item:** Borde
  - **FoNAO category:** 33
  - **Trial conditions/treatment:** 22°C
  - **Treatment time:** 24 hrs
  - **Increase/ decrease:** +6.6 log/cfu/ml
  - **Reference(s):** Tadesse et al., 2005

- **Pathogen:** Rotavirus (SA11)
  - **Food item:** Borde
  - **FoNAO category:** 33
  - **Trial conditions/treatment:** 22°C
  - **Treatment time:** 24 hrs
  - **Increase/ decrease:** > 7 log cfu/ml
  - **Reference(s):** Tadesse et al., 2005

*a no quantitative data reported*
## Table 16: Colonization behaviour of pathogenic bacteria linked to FoNAO with low water content.

| Pathogen                   | FoNAO category | Food item               | Attach-ment<sup>a</sup> | Biofilm Formation<sup>b</sup> | Internali-ation<sup>b</sup> | Details<sup>b</sup>                                                                                     | Reference(s)                                           |
|---------------------------|----------------|-------------------------|--------------------------|-------------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| *Bacillus cereus*         | 25             | Rice                    | n.d                      | n.d                           | yes                         | Significantly different mean D95°C-values of spores of the emetic (19.3 min) and the diarrheal (2.8 min) types | Ankolekar and Labbe, 2009                               |
|                           |                | cooked rice             | n.d                      | n.d                           | yes                         | Growth depends on storage temperature and pH of the cooked rice                                         | Heo et al., 2009                                      |
| *Escherichia coli*        | 14             | bean sprouts            | n.d                      | yes                           | yes                         | *E. coli* present on seeds become internalized within the subsequent sprouts and cannot be removed by postharvest biocidal washing | Warriner et al., 2003                                  |
| *Escherichia coli*        | 28             | alfalfa sprouts         | yes                      | n.d                           | n.d                         | attachment dependent on serotype                                                                         | Barak et al., 2002                                    |
| *Listeria monocytogenes*  | 28             | sprouts (alfalfa, radish, broccoli) | yes                      | n.d                           | n.d                         |                                                                                                         | Gorski et al., 2008                                   |
|                           |                | alfalfa sprouts         | yes                      | n.d                           | yes                         |                                                                                                         | Gorski et al., 2004                                   |
| *Listeria spp.*           | 24             | barley                  | yes                      | n.d                           | yes                         | *Listeria* spp. colonized the root hair zone but did not colonize other parts of the root surface; endophytic colonization of *Listeria* spp. was not observed | Kutter et al., 2006                                   |
| *Salmonella enterica*     | 24             | barley                  | yes                      | n.d                           | yes                         | high-density colonization of root hairs and root surface; also spreading to subjacent rhizodermis layers and the inner root cortex. | Kutter et al., 2006                                   |
| *Salmonella enterica*     | 28             | alfalfa sprouts         | yes                      | n.d                           | n.d                         | not dependent on serotype                                                                                                           | Barak et al., 2002                                   |
| *Salmonella Typhimurium*  | 14             | bean sprouts            | n.d                      | yes                           | yes                         | *Salmonella* spp. present on seeds become internalized within the subsequent sprouts and cannot be removed by postharvest biocidal washing                                          | Warriner et al., 2003                                 |
| *Salmonella Montevideo*   | 31             | peanut                  | n.d                      | n.d                           | yes                         | Average 13.6 cells/mm<sup>3</sup>; *S. Typhimurium* contaminates peanut seeds, persists within the germinated seedlings, and is internalized within peanut tissue.                      | Deering et al., 2012                                  |

<sup>a</sup>n.d. = not determined  <sup>b</sup>n.r. = not reported
Table 17: Treatments for mitigating contamination of pathogenic bacteria linked to FoNAO with low water content.

| Pathogen                      | FoNAO category | Food item          | Treatment characterisation | Treatment | Conditions | Time | Reduction Effect | Reference(s) |
|-------------------------------|----------------|--------------------|---------------------------|-----------|------------|------|------------------|--------------|
| Bacillus cereus               | 27             | Corn Snacks        | Physical                  | Irradiation, gamma | $^{60}$Co gamma cell: 7, 8 and 9 kGy; initial counts ranging from $3 \times 10^3$ to $6 \times 10^3 \, \text{cfu/g}$ | n.s. | complete elimination of bacterial spores, required dose correlated with initial counts | Zeid, 2009 |
| Cronobacter spp.              | 33             | Herbal Infant Teas | Biological                | Bovine lactoferrin | 5 or 10 mg/ml; 37°C; enrichment to a final concentration of ~ 4 log CFU/mL | 4 h  | no viable cells (plating in duplicate on TSA, incubated at 37°C for 24h) | Al-Nabulsi et al., 2009 |
| Enterococcus faecalis         | 31             | Almonds            | Physical                  | Hot water      | minimum temperature of 88°C | 1.6 to 2.0 min | 5 to 6 log CFU/g reduction | Harris et al., 2012 |
| Escherichia coli O157:H7 (EHEC) | 28             | Alfalfa seeds      | Physical                  | High hydrostatic pressure | soaked in water, followed by 60 min; 600 Mpa for 2 min at 20°C; inoculation to $10^3 \, \text{CFU/g}$ | 15 min | complete elimination, germination rate of seeds 4% lower than untreated | Neetoo and Chen, 2009 |
| Escherichia coli O157:H7 (EHEC) | 28             | Broccoli seeds     | Physical                  | Irradiation, gamma | 1.1 kGy | n.s. | D-values: 1-log CFU reduction | Rajkowski et al., 2003 |
| Escherichia coli O157:H7 (EHEC) | 28             | Radish seeds and sprouts | Chemical + Physical        | Chlorine dioxide + drying and dry heat | ClO$_2$ (500 µg/ml, 5 min), drying (45°C, 23% rel. humidity, 24 h), and dry heat (70°C, 23% rel. humidity, 48h) | n.s. | Complete elimination (~5.9 log CFU/g) | Bang et al., 2011 |
| Escherichia coli O157:H7 (EHEC) | 31             | Peanut Butter      | Physical                  | Thermal treatment | 30 days incubation period at 4°C and thermal treatment 72°C | 60 min | 1.5 log CFU reduction | He et al., 2011 |
| Escherichia coli O157:H7 (EHEC) | 31             | Peanut Butter      | Physical                  | Thermal treatment | 30 days incubation period at 25°C and thermal treatment 72°C | 60 min | 1.5 log CFU reduction | He et al., 2011 |
| Escherichia coli O157:H7 (EHEC) | 31             | Peanut Butter      | Physical                  | Thermal treatment | 30 days incubation period at 4°C and thermal treatment 90°C | 60 min | 6 log CFU reduction | He et al., 2011 |
| Pathogen                  | FoNAO category | Food item                  | Treatment characterisation | Treatment           | Conditions                                                                 | Timea | Reduction Effect          | Reference(s)         |
|--------------------------|----------------|----------------------------|----------------------------|---------------------|-----------------------------------------------------------------------------|-------|--------------------------|----------------------|
| Escherichia coli O157:H7 (EHEC) | 31             | Peanut Butter              | Physical                   | Thermal treatment   | 30 days incubation period at 25°C and thermal treatment 90°C                | 60 min | 7 log CFU reduction      | He et al., 2011      |
| Listeria monocytogenes   | 27             | Kunun-zaki (a sorghum based beverage) | Physical                   | Thermal treatment + acidity | pH 5.4; 50°C                                                               | n.s.  | D-value: 24 min          | Ariahu et al., 2005  |
| Listeria monocytogenes   | 27             | Kunun-zaki (a sorghum based beverage) | Physical                   | Thermal treatment + acidity | pH 5.4; 65°C                                                               | n.s.  | D-value: 0.16 min        | Ariahu et al., 2005  |
| Listeria monocytogenes   | 27             | Kunun-zaki (a sorghum based beverage) | Physical                   | Thermal treatment + acidity | pH 6.6; 50°C                                                               | n.s.  | D-value: 45.1 min        | Ariahu et al., 2005  |
| Listeria monocytogenes   | 27             | Kunun-zaki (a sorghum based beverage) | Physical                   | Thermal treatment + acidity | pH 6.6; 65°C                                                               | n.s.  | D-value: 0.35 min        | Ariahu et al., 2005  |
| Listeria monocytogenes   | 28             | Alfalfa sprout             | Physical                   | Irradiation, beta    | 3.3 or 5.3 kGy                                                             | n.s.  | from 6 log CFU/g to completely eliminated | Schoeller et al., 2002 |
| Salmonella Enterica      | 31             | Peanut Butter              | Physical                   | Thermal treatment    | 30 days incubation period at 4°C and thermal treatment 72°C                | n.s.  | D-value: 18.38 min       | He et al., 2011      |
| Salmonella Enterica      | 31             | Peanut Butter              | Physical                   | Thermal treatment    | 30 days incubation period at 25°C and thermal treatment 72°C               | n.s.  | D-value: 16.94 min       | He et al., 2011      |
| Salmonella Enterica      | 31             | Peanut Butter              | Physical                   | Thermal treatment    | 30 days incubation period at 4°C and thermal treatment 90°C               | n.s.  | D-value: 5.08 min        | He et al., 2011      |
### Pathogen and Food Item Details

| Pathogen                | FoNAO category | Food item | Treatment characterisation | Treatment | Conditions | Time | Reduction Effect | Reference(s) |
|-------------------------|----------------|-----------|----------------------------|-----------|------------|------|-----------------|--------------|
| *Salmonella enterica*   | 31             | Peanut Butter | Physical | Thermal treatment | 30 days incubation period at 25°C and thermal treatment 90°C | n.s. | D-value: 5.40 min | He et al., 2011 |
| *Salmonella enteritidis*| 31             | Almonds    | Chemical | Propylene Oxide | 0.5 kg/m³ | 4 h | > 5 log CFU/g | Danyluk et al., 2005 |
| *Salmonella enteritidis*| 31             | Almonds    | Physical | Hot water | minimum temperature of 88°C | 1.6 to 2.0 min | 5 log CFU reduction | Harris et al., 2012 |
| *Salmonella senftenberg*| 31             | Almonds    | Physical | Hot water | minimum temperature of 88°C | 1.6 to 2.0 min | 5 log CFU reduction | Harris et al., 2012 |
| *Salmonella spp.*       | 28             | Broccoli seeds | Physical | Irradiation, gamma | 1.1 kGy | n.s. | D-values: 1-log CFU reduction | Rajkowski et al., 2003 |

n.s. = not specified

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### Table 18: Outbreaks of disease caused by pathogenic bacteria and viruses linked to FoNAO with low water content, EU countries. n.s.= not specified. n.r.= not reported.

| Pathogen              | FoNAO category | Food item      | Details (vehicle, source) | Country | Year | Number cases | Number hospitalisations | Number deaths | Reference(s) |
|-----------------------|----------------|----------------|---------------------------|---------|------|--------------|------------------------|---------------|--------------|
| *Bacillus cereus*     | 24             | Buckwheat      | n.r.                      | Poland  | 2009 | 52           | 0                      | 0             | ECDC, 2009    |
| *Bacillus cereus*     | 25             | Rice           | rice pudding              | Germany | 2007 | 46           | 0                      | 0             | Kamba Wambo et al., 2011 |
| *Bacillus cereus*     | 25             | Rice           | n.r.                      | Netherlands | 2009 | 3            | n.s.                  | n.s.          | ECDC, 2009    |
| *Bacillus cereus*     | 25             | Rice           | n.r.                      | Netherlands | 2009 | 3            | n.s.                  | n.s.          | ECDC, 2009    |
| *Bacillus cereus*     | 25             | Rice           | n.r.                      | Netherlands | 2009 | 3            | n.s.                  | n.s.          | ECDC, 2009    |
| *Bacillus cereus*     | 25             | Rice           | n.r.                      | Netherlands | 2009 | 2            | n.s.                  | n.s.          | ECDC, 2009    |
| Pathogen                  | FoNAO category | Food item                  | Details (vehicle, source) | Country         | Year | Number cases | Number hospitali-sations | Number deaths | Reference(s)               |
|--------------------------|----------------|---------------------------|----------------------------|-----------------|------|--------------|----------------------------|---------------|---------------------------|
| Bacillus cereus          | 25             | Rice                      | rice and indian lentils    | Germany         | 2010 | 3            | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 26             | Pasta salad               | n.r.                       | Belgium         | 2004 | 5            | 5                          | 1             | Dierick et al., 2005      |
| Bacillus cereus          | 27             | Cereal products including rice and seeds/pulses | n.r.                       | Belgium         | 2010 | 9            | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 27             | Cereal products including rice and seeds/pulses | Chinese rice/noodle dish | Netherlands     | 2010 | 2            | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 27             | Cereal products including rice and seeds/pulses | Chinese noodle dish        | Netherlands     | 2010 | 2            | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 27             | Cereal products including rice and seeds/pulses | Chinese rice dish          | Netherlands     | 2010 | 2            | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 32             | Curry                     | n.r.                       | Belgium         | 2009 | 7            | 0                          | 0             | ECDC, 2009                 |
| Bacillus cereus          | 32             | White pepper              | n.r.                       | Denmark         | 2010 | 112          | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 37             | Cereal products including rice and seeds/pulses | pastes                    | Slovakia        | 2009 | 16           | 0                          | 0             | ECDC, 2009                 |
| Bacillus cereus          | 37             | Falafel                   | n.r.                       | Netherlands     | 2009 | 2            | n.s.                       | n.s.          | ECDC, 2009                 |
| Bacillus cereus          | 37             | Kisir                     | cereal product including rice and seeds, Turkish salad | Finland | 2010 | 8            | 0                          | 0             | ECDC, 2010                 |
| Bacillus cereus          | 37             | Pesto                     | n.r.                       | Netherlands     | 2009 | 2            | n.s.                       | n.s.          | ECDC, 2009                 |
| Clostridium perfringens  | 25             | Rice                      | duck rice, cooked          | Portugal         | 2009 | 5            | n.s.                       | 0             | ECDC, 2009                 |
| Escherichia coli O104:H4 (STEC O104:H4) | 28 | Sprouts, fenugreek seeds | seeds from Egypt, sprouts from Germany and France | Germany, France, other EU countries plus Norway | 2011 | 4033 | n.s. | 50 | CDC, 2011, online(e), Buchholz et al., 2011, EFSA, 2011; Frank et al., 2011, King et al., 2012, Kemper 2012 |

Supporting publications 2013:EN-403

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| Pathogen               | FoNAO category | Food item | Details (vehicle, source) | Country       | Year     | Number cases | Number hospitalizations | Number deaths | Reference(s)                      |
|------------------------|----------------|-----------|---------------------------|---------------|----------|--------------|-------------------------|--------------|----------------------------------|
| Salmonella Bareilly    | 28             | Bean sprouts | n.r.                      | United Kingdom | 2010     | 231          | 32                      | 1            | ECDC, 2010; Cleary et al., 2010 |
| Salmonella Bareilly    | 28             | Bean sprouts | n.r.                      | United Kingdom | 2010     | 21           | 3                       | 0            | ECDC, 2010                       |
| Salmonella Bovismorbidicans | 28               | Alfalfa sprouts | raw                      | Finland       | 2009     | 28           | 0                       | 0            | ECDC, 2009; Rimhanen-Finne et al., 2011 |
| Salmonella Bovismorbidicans | 28               | Sprouts     | n.r.                      | Estonia       | 2009     | 6            | 3                       | 0            | ECDC, 2009                       |
| Salmonella enterica    | 32             | Aniseed    | n.r.                      | Germany       | 2002-2003 | 42           | 0                       | 0            | Koch et al., 2005                |
| Salmonella Enteritidis | 24             | Corn       | grits with sweet milk    | Hungary       | 2010     | 17           | 4                       | 0            | ECDC, 2010                       |
| Salmonella Enteritidis | 26             | Noodles    | n.r.                      | Hungary       | 2010     | 18           | 1                       | 0            | ECDC, 2010                       |
| Salmonella Enteritidis | 27             | Bakery products | n.r.                    | France        | 2009     | 4            | 0                       | 0            | ECDC, 2009                       |
| Salmonella Enteritidis | 27             | Bakery products | layer cakes              | Lithuania     | 2009     | 11           | 6                       | 0            | ECDC, 2009                       |
| Salmonella Enteritidis | 27             | Bakery products | cakes                   | Lithuania     | 2009     | 10           | 6                       | 0            | ECDC, 2009                       |
| Salmonella Enteritidis | 27             | Bakery products | fine bakery product containing pasteurized dairy products and raw eggs | Poland | 2009 | 243 | 93 | 0 | ECDC, 2009 |
| Salmonella Enteritidis | 27             | Bakery products | n.r.                    | Poland        | 2009     | 10           | 8                       | 0            | ECDC, 2009                       |
| Salmonella Enteritidis | 27             | Bakery products | n.r.                    | Poland        | 2009     | 3            | 2                       | 0            | ECDC, 2009                       |
| Salmonella Enteritidis | 27             | Bakery products | dumpling                 | Slovakia      | 2009     | 85           | 11                      | 0            | ECDC, 2009                       |
| Pathogen                     | FoNAO category | Food item          | Details (vehicle, source)<sup>a</sup>                                      | Country     | Year | Number cases | Number hospitali-sations<sup>b</sup> | Number deaths<sup>b</sup> | Reference(s)        |
|------------------------------|----------------|--------------------|-----------------------------------------------------------------------------|-------------|------|--------------|-------------------------------------|-------------------------|---------------------|
| *Salmonella* Enteritidis     | 27             | Bakery products    | apple pie with royal icing                                                  | Slovakia    | 2009 | 20           | 1                                    | 0                       | ECDC, 2009          |
| *Salmonella* Enteritidis     | 27             | Bakery Products    | n.r.                                                                         | Austria     | 2010 | 22           | 6                                    | 0                       | ECDC, 2010          |
| *Salmonella* Enteritidis     | 27             | Bakery Products    | cake filled with heated creme                                                | Germany     | 2010 | 9            | 2                                    | 0                       | ECDC, 2010          |
| *Salmonella* Enteritidis     | 27             | Bakery Products    | fine bakery product containing pasteurized dairy products and raw eggs       | Poland      | 2010 | 273          | 89                                   | 0                       | ECDC, 2010          |
| *Salmonella* Enteritidis     | 27             | Bakery Products    | farm (primary production)                                                   | Poland      | 2010 | 11           | 8                                    | 0                       | ECDC, 2010          |
| *Salmonella* Enteritidis     | 27             | Bakery Products    | n.r.                                                                         | Poland      | 2010 | 11           | 5                                    | 0                       | ECDC, 2010          |
| *Salmonella* Enteritidis     | 31             | Almonds            | raw                                                                          | Sweden      | 2005-2006 | 15         | n.s.                                | n.s.                   | Ledet Müller et al., 2007 |
| *Salmonella* Enteritidis     | 33             | Sweets and chocolate| n.r.                                                                         | Hungary     | 2009 | 35           | 5                                    | 0                       | ECDC, 2009          |
| *Salmonella* Enteritidis     | 33             | Sweets and chocolate| n.r.                                                                         | Hungary     | 2009 | 4            | 0                                    | 0                       | ECDC, 2009          |
| *Salmonella* Infantis        | 37             | Falafel            | n.r.                                                                         | Sweden      | 2010 | 18           | 0                                    | 0                       | ECDC, 2010          |
| *Salmonella* Kottbus         | 28             | Bean sprouts       | n.r.                                                                         | United Kingdom | 2010 | 4            | 0                                    | 0                       | ECDC, 2010          |
| *Salmonella* Madelia         | 26             | Tortellini         | with pesto                                                                   | Germany     | 2002 | 18           | 2                                    | n.s.                   | Hauri et al., 2004   |
| *Salmonella* Montevideo      | 27             | Hemp flour         | n.r.                                                                         | Germany     | 2010 | 4            | 1                                    | 0                       | ECDC, 2010, Stöcker et al., 2011 |
| *Salmonella* spp.            | 27             | Bakery products    | n.r.                                                                         | France      | 2009 | 15           | 2                                    | 0                       | ECDC, 2009          |
| *Salmonella* spp.            | 27             | Bakery Products    | n.r.                                                                         | France      | 2010 | 22           | 3                                    | 0                       | ECDC, 2010          |

<sup>a</sup> Details of the vehicle and source of contamination.

<sup>b</sup> Number of hospitalisations and deaths.

ECDC, European Centre for Disease Control; n.s., not specified.
| Pathogen                     | FoNAO category | Food item                  | Details (vehicle, source)\(^a\) | Country     | Year | Number cases | Number hospitalisations\(^b\) | Number deaths\(^b\) | Reference(s)            |
|-----------------------------|----------------|----------------------------|----------------------------------|-------------|------|--------------|-------------------------------|-----------------------|-------------------------|
| Salmonella spp.             | 27             | Bakery Products            | n.r.                             | France      | 2010 | 10           | 5                             | 0                     | ECDC, 2010               |
| Salmonella spp.             | 33             | Sweets and chocolate       | n.r.                             | Romania     | 2010 | 14           | 12                            | 1                     | ECDC, 2010               |
| Salmonella Stanley          | 28             | Alfalfa sprouts            | n.r.                             | Sweden      | 2007 | 51           | n.s.                          | n.s.                  | Werner et al., 2007      |
| Salmonella Typhimurium      | 27             | Bakery Products            | n.r.                             | France      | 2010 | 8            | 0                             | 0                     | ECDC, 2010               |
| Salmonella Weltvreden       | 28             | Alfalfa sprouts            | n.r.                             | Norway, Sweden, Denmark, Finland | 2007 | 45           | n.s.                          | n.s.                  | Emberland et al., 2007  |
| Shigella sonnei             | 14             | Corn                       | baby corn                        | Denmark     | 2007 | 120          | 13                            | n.s.                  | Lewis et al., 2007       |
| Staphylococcus aureus       | 26             | Pasta                      | cooked, with chicken             | Portugal    | 2009 | 16           | n.s.                          | 0                     | ECDC, 2009               |
| Staphylococcus aureus       | 26             | Spaghetti                  | n.r.                             | Belgium     | 2009 | 10           | 0                             | 0                     | ECDC, 2009               |
| Staphylococcus aureus       | 27             | Bakery Products            | infected food handler            | France      | 2010 | 87           | 5                             | 0                     | ECDC, 2010               |
| Staphylococcus aureus       | 33             | Sweets and chocolate       | n.r.                             | Romania     | 2010 | 5            | 5                             | 0                     | ECDC, 2010               |
| Staphylococcus aureus       | 37             | Cereal products            | including rice and seeds/pulses | n.r.        | France | 2009 | 2           | 0                             | 0                     | ECDC, 2009               |
| Yersinia enterocolitica     | 25             | Rice                       | cooked, with codfish             | Portugal    | 2009 | 21           | 1                             | 1                     | ECDC, 2009               |
| Viruses                     |                |                            |                                  |             |      |              |                               |                       |                         |
| Calicivirus norovirus       | 25             | Rice                       | sushi rice                       | Sweden      | 2009 | 28           | 0                             | 0                     | ECDC, 2009               |
| (Norwalk-like virus)        |                |                            |                                  |             |      |              |                               |                       |                         |
| Calicivirus norovirus       | 33             | Sweets and chocolate       | n.r.                             | Hungary     | 2010 | 25           | 0                             | 0                     | ECDC, 2010               |
| (Norwalk-like virus)        |                |                            |                                  |             |      |              |                               |                       |                         |
| Hepatitis A virus           | 27             | Bakery Products            | doughnuts                        | Germany     | 2004 | 64           | n.s.                          | n.s.                  | Schenkel et al., 2006   |

\(^a\) n.r.= not reported  
\(^b\) n.s.= not specified  

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Table 19: Outbreaks of disease caused by pathogenic bacteria linked to FoNAO with low water content, non EU countries.

| Pathogen                  | FoNAO category | Food item                        | Source, Processing Stage | Country          | Year   | Number cases | Number hospital | Number deaths | Reference(s)                          |
|---------------------------|----------------|----------------------------------|--------------------------|------------------|--------|--------------|----------------|--------------|---------------------------------------|
| *Clostridium botulinum*   | 37             | Bamboo shoots                     | n.r.                     | Thailand         | 2006   | 209          | 25             | 0            | Kongsaengdao et al., 2006             |
| *Escherichia coli* O157   | 28             | Alfalfa sprouts                   | n.r.                     | USA              | 2003   | 7            | 2              | 0            | Ferguson et al., 2005                 |
| *Escherichia coli* O157:H7| 31             | Hazelnut                          | in shell hazelnuts, retail food stores | Multi-state outbreak states | 2011 | 8            | 4              | 0            | CDC, online(h); Miller et al., 2012   |
| *Escherichia coli* O26    | 28             | Clover sprouts                    | raw, at restaurant chain | Multi-state outbreak states | 2012 | 29           | 7              | 0            | CDC, online(c) updated 10-10-2012     |
| *Salmonella Agona*        | 37             | Cereals                           | Malt-O-Meal unsweetened Puffed Rice Cereals and unsweetened Puffed Wheat Cereals | Multi-state outbreak states | 2008 | 28           | 8              | 0            | CDC, online(c) 2008                  |
| *Salmonella Enteritidis*  | 31             | Turkish Pine Nuts                 | bulk bins at grocery stores | Multi-state outbreak states | 2011 | 43           | 2              | 0            | CDC, online(f) 2011                  |
| *Salmonella Enteritidis*  | 28             | Alfalfa sprouts and spicy sprouts | manufactured by Fresh Evergreen Sprouts | Multi-state outbreak states | 2011 | 25           | 3              | 0            | CDC, online(g) 2011                  |
| *Salmonella Enteritidis*  | 37             | Cake or Bread                     | n.r.                     | China            | 2004   | 199          | 92             | n.s. | Liu et al., 2006                     |
| *Salmonella Enteritidis*  | 31             | Almonds                           | raw                      | USA, Canada      | 2003-2004 | 29          | 0              | 0            | MMWR, 2004c                          |
| *Salmonella Enteritidis*  | 28             | Bean sprouts                      | n.r.                     | Canada           | 2005   | 592          | n.s.           | n.s. | Rohekar et al., 2008                 |
| *Salmonella Montevideo*   | 32             | Black and red pepper              | production of Italian-style meats | Multi-state outbreak states | 2010 | 272          | 52             | 0            | CDC, online(c) 2010                  |
### Pathogen, FoNAO category, Food item, Source, Processing Stage, Country, Year, Number of cases, Number of hospital admissions, Number of deaths, Reference(s)

| Pathogen                          | FoNAO category | Food item          | Source, Processing Stage | Country                      | Year | Number of cases | Number of hospital admissions | Number of deaths | Reference(s)          |
|-----------------------------------|----------------|--------------------|--------------------------|------------------------------|------|-----------------|-------------------------------|------------------|-----------------------|
| Salmonella Newport                | 28             | Alfalfa Sprouts    | n.r.                     | Multi-state outbreak USA     | 2010 | 44              | 7                             | 0                | CDC, online(e)         |
| Salmonella Saintpaul              | 28             | Alfalfa Sprouts    | n.r.                     | Multi-state outbreak USA     | 2009 | 235             | 7                             | 0                | CDC, online(b); MMWR, 2009b |
| Salmonella serotype I 4,[5],12:i:- | 28             | Alfalfa Sprouts    | n.r.                     | Multi-state outbreak USA     | 2010 | 140             | 33                            | 0                | CDC, online(d)         |
| Salmonella Tennessee              | 31             | Peanut Butter      | n.r.                     | Multi-state outbreak USA     | 2007 | 425             | 71                            | 0                | CDC, online(b); Boehmer et al., 2009, Sheth et al., 2011, MMWR, 2007b |
| Salmonella Typhimurium            | 31             | Peanut Butter      | n.r.                     | Multi-state outbreak USA     | 2009 | 715             | 171                           | 9                | CDC, online(a); MMWR, 2009a |
| Salmonella Wandsworth; Salmonella Typhimurium | 27             | Cereals snack of puffed rice and corn | Multistate outbreak USA, Canada | 2007 | 65              | 6                             | 0                | CDC, online(c)         |
| Shigella sonnei                   | 14             | Corn               | baby corn                | Australia                     | 2007 | 58              | n.s.                          | n.s.             | Stafford et al., 2007   |

\(^a\)n.r.= not reported  
\(^b\)n.s.= not specified
## B. Appendix Specific to Thematic Area B

### Table 20: Categories and items of FoNAO with low water content as reported in association with pathogenic bacteria. “Country” signifies the place where the food commodity was found in association with the biological contaminant (e.g. site of survey or screening).

| FoNAO Category | Food item | Pathogen | Country | Reference(s) |
|----------------|-----------|----------|---------|--------------|
| 24 Cereals and dry legumes | Barley | *Bacillus cereus* | Korea | Park et al., 2008 |
| | Breakfast cereals | *Cronobacter spp.*, *Bacillus cereus* | Ireland, Malaysia | Molloy et al., 2009; Lee et al., 2009 |
| | Cereal | *Bacillus cereus* | Korea | Park et al., 2008 |
| | Grains | *Cronobacter spp.* | Korea | Chon et al., 2012 |
| | Job’s tears (*Coix lacrymajobi*) | *Bacillus cereus* | Korea | Park et al., 2008 |
| | Lentils | *Cronobacter dublinensis* | Czech Republic | Hochel et al., 2012 |
| | Maize; porridge | *Salmonella spp.* | Kenya | Muoki et al., 2008 |
| | Maize; ugali | *Salmonella spp.* | Kenya | Muoki et al., 2008 |
| | Wheat | *Bacillus cereus, Staphylococcus aureus* | Turkey, Australia | Alp et al., 2008; Berghofer et al., 2003 |
| | Wheat flour | *Bacillus cereus* | Turkey, Argentina | Segun et al., 2012; Fangio et al., 2010 |
| | Wheat grain | *Bacillus cereus, Salmonella spp.* | Australia | Eglezos 2010a |
| | Wheat grass | *Salmonella spp.* | India | Titarmare et al., 2009 |
| 25 Rice | Basmati rice | *Bacillus cereus* spp. group | Belgium | Samapundo et al., 2011 |
| | Brown rice | *Bacillus cereus* | Korea | Park et al., 2008 |
| | Fried rice with vegetable/Chinese-Style | *Bacillus cereus* | Sri Lanka | Perera and Ranasinghe 2012 |
| | Glutinous rice | *Bacillus cereus* | Korea | Park et al., 2008 |
| | Kimbap; korean snack | *Staphylococcus aureus* | Korea | Oh et al., 2007 |
| | Nem choa | *Staphylococcus aureus* | Japan, Vietnam, Bagladesch | Huong et al. 2010 |
| FoNAO Category | Food item | Pathogen | Country | Reference(s) |
|----------------|-----------|----------|---------|--------------|
| Rice           | B. cereus, Pseudomonas aeruginosa, Salmonella Typhi, Shigella sonnei, B. cereus like organism | Nigeria, Italy, Belgium, Denmark | Isara et al., 2010; Bonerba et al., 2010; Delbrassinne et al., 2012; Rosenquist et al., 2005 |
| Rice (brown, white, wild type, black and rice mixtures) | B. cereus | USA | Ankolekar et al., 2009 |
| Rice cake      | S. aureus | Japan, Vietnam, Bangladesh | Huong et al.2010 |
| Rice cakes with filling | S. aureus | Korea | Oh et al., 2007 |
| Rice cakes without filling | S. aureus | Korea | Oh et al., 2007 |
| Sticky rice    | S. aureus | Japan, Vietnam, Bangladesh | Huong et al.2010 |
| 26 Pasta       | Pasta     | B. cereus spp. Group, B. cereus like organism | Belgium, Denmark | Samapundo et al., 2011; Rosenquist et al., 2005 |
| 27 Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products) | Bakery products | Salmonella Enteritidis, Listeria monocytogenes, Cronobacter sakazakii | Spain, Lithuania, Germany | ECDC, 2008; ECDC, 2010 |
| Bakery products (cakes) | Salmonella Enteritidis | Slovakia | ECDC, 2008 |
| Bakery products (desserts) | Salmonella spp. | Spain | ECDC, 2009 |
| Biscuits (Infant food) | B. cereus | Korea | Kim et al., 2011a |
| Bran           | B. cereus | Australia | Berghofer et al., 2003 |
| Bread          | S. aureus | Korea | Oh et al., 2007 |
| Buckwheat vermicelli | S. aureus | Korea | Oh et al., 2007 |
| Cakes          | L. monocytogenes | Croatia | Uhitil et al., 2004 |
| Cereal based food | S. aureus | Nigeria | Olasupo et al., 2002 |
| Cereal products | B. cereus | Malaysia | Lee et al., 2009 |
| Cereal products | Cronobacter sakazakii | Korea | Lee et al., 2012 |
| Cereals and meals | Salmonella spp. , Listeria monocytogenes, Staphylococcal enterotoxins | Luxembourg, Ireland | ECDC, 2009; ECDC, 2008 |
| Coconut biscuits | Cronobacter sakazakii | Czech Republic | Hochel et al., 2012 |
| FoNAO Category                          | Food item                                           | Pathogen                                                                 | Country                      | Reference(s)                          |
|-----------------------------------------|-----------------------------------------------------|---------------------------------------------------------------------------|------------------------------|---------------------------------------|
| Confectionery products and pastes       | Confectionery products and pastes                  | *Salmonella Enteritidis*, *Listeria monocytogenes*, Staphylococcal enterotoxins | Hungary, Slovakia            | ECDC, 2008; ECDC, 2009               |
| Cream-bread                             | Cream-bread                                         | *Staphylococcus aureus*                                                   | Korea                        | Oh et al., 2007                       |
| Cream-cake                              | Cream-cake                                          | *Staphylococcus aureus*                                                   | Korea                        | Oh et al., 2007                       |
| Dried adults cereals                    | Dried adults cereals                                | *Cronobacter sakazakii*                                                  | USA                          | Restaino et al., 2006                |
| Dried cereals                           | Dried cereals                                       | *Cronobacter spp.*                                                       | Netherlands                  | Kandhai et al., 2010                 |
| Dried flour or meals (Corn, soy, wheat and rice) | Dried flour or meals (Corn, soy, wheat and rice) | *Cronobacter sakazakii*                                                  | USA                          | Restaino et al., 2006                |
| Dried infant cereals                    | Dried infant cereals                                | *Cronobacter sakazakii*                                                  | USA                          | Restaino et al., 2006                |
| Flour                                   | Flour                                               | *Bacillus cereus*, *Listeria monocytogenes*, *Cronobacter (E. agglomerans)* | Australia, Portugal, Jordan | Berghofer et al., 2003; Mena et al., 2004; Shaker et al., 2007 |
| Grains and beans                        | Grains and beans                                    | *Cronobacter spp.*                                                       | Korea                        | Kim et al., 2011b                     |
| Hosmerim dessert                        | Hosmerim dessert                                    | *Staphylococcus aureus*, *Listeria monocytogenes*                        | Turkey                       | Cokal et al., 2012                   |
| Maize flour porridge                    | Maize flour porridge                                | *Staphylococcus aureus*, *Salmonella spp.*                              | Malawi                       | Taulo et al., 2008                   |
| Mandazi; chapati                        | Mandazi; chapati                                    | *Salmonella spp.*                                                        | Kenya                        | Muoki et al., 2008                   |
| Noodles                                 | Noodles                                             | *Salmonella spp., Salmonella Enteritidis*                                | Ireland, Slovakia, Hungary   | ECDC, 2009, ECDC, 2008               |
| Oat flakes                              | Oat flakes                                          | *Cronobacter sakazakii*                                                  | Czech Republic               | Hochel et al., 2012                  |
| Pastries                                | Pastries                                            | *Cronobacter sakazakii/Cronobacter malonicus*, *Listeria monocytogenes*  | Slovakia, Portugal           | Turcovský et al., 2011; Mena et al., 2004 |
| Powdered infant formula milk            | Powdered infant formula milk                        | *Staphylococcus aureus*                                                  | China, USA                   | Wang et al., 2012                    |
| Pre-mixed drinks                        | Pre-mixed drinks                                    | *Bacillus cereus*                                                        | Malaysia                     | Lee et al., 2009                     |
| Raw cereals                             | Raw cereals                                         | *Bacillus cereus*                                                        | Malaysia                     | Lee et al., 2009                     |
| Rice flour                              | Rice flour                                          | *Cronobacter sakazakii/Cronobacter malonicus/Cronobacter dublinensis     | Czech Republic               | Hochel et al., 2012                  |
| Semolina                                | Semolina                                            | *Cronobacter (E. agglomerans), Cronobacter sakazakii                    | Jordan                       | Shaker et al., 2007                  |
| Starch                                  | Starch                                              | *Cronobacter (E. agglomerans)*                                           | Jordan                       | Shaker et al., 2007                  |
| FoNAO Category | Food item | Pathogen | Country | Reference(s) |
|----------------|-----------|----------|---------|--------------|
|                | Sunsik    | *Cronobacter sakazakii, Cronobacter spp., Cronobacter dublinensis, Cronobacter muytjensii* | Korea   | Kim et al., 2008; Lee et al., 2012 |
|                | Vhuswa    | *Shigella spp., Salmonella spp., Campylobacter jejuni* | South Africa | Potgieter et al., 2007; Potgieter et al., 2006; Potgieter et al., 2005 |
|                | Wheat germ | *Bacillus cereus* | Australia | Berghofer et al., 2003 |
|                | **Seeds for sprouting and sprouted seeds** | | | |
|                  | Alfalfa seeds | *Salmonella spp.* | United Kingdom + Import | Willis et al., 2009 |
|                  | Alfalfa sprouts | *Listeria monocytogenes* | Korea | Waje et al., 2009 |
|                  | Broccoli sprouts | *Listeria monocytogenes* | Korea | Waje et al., 2009 |
|                  | Linseed (flax) | *Salmonella spp.* | United Kingdom + Import | Willis et al., 2009 |
|                  | Melon (egusi) | *Salmonella spp.* | United Kingdom + Import | Willis et al., 2009 |
|                  | Mung bean sprout | *Campylobacter jejuni, Campylobacter coli* | Malaysia | Chai et al., 2007 |
|                  | Poppy seed | *Cronobacter sakazakii* | Czech Republic | Hochel et al., 2012 |
|                  | Pumpkin seed | *Cronobacter sakazakii/Cronobacter malonicicus/Cronobacter turicensis* | Czech Republic | Hochel et al., 2012 |
|                  | Red radish sprouts | *Listeria monocytogenes* | Korea | Waje et al., 2009 |
|                  | Seasame | *Salmonella spp.* | United Kingdom + Import | Willis et al., 2009 |
|                  | Seeds | *Salmonella spp., Listeria monocytogenes* | Netherlands, Romania, Hungary | ECDC, 2009 |
|                  | Seeds mixed | *Salmonella spp.* | United Kingdom + Import | Willis et al., 2009 |
|                  | Seeds, sprouted | *Salmonella spp.* | Germany | ECDC, 2008 |
|                  | Sesam seed | *Salmonella spp., Cronobacter sakazakii/Cronobacter malonicicus* | Germany, Czech Republic | Brockmann et al., 2004; Hochel et al., 2012 |
|                  | Soybean sprout | *Yersinia enterocolitica* | Korea | Lee et al., 2004 |
| FoNAO Category      | Food item                          | Pathogen                                      | Country          | Reference(s)                  |
|---------------------|------------------------------------|-----------------------------------------------|------------------|------------------------------|
| Sprouts             | Cronobacter sakazakii, Cronobacter spp., Listeria monocytogenes | Korea, Swiss                                  | Kim et al., 2009; Althaus et al., 2012; Waje et al., 2009 |
| Sprouts (Phaseolus vulgaris) | Bacillus cereus                  | Venezuela                                     | Cava et al., 2009 |
| Sunflower           | Salmonella spp.                   | United Kingdom + Import                       | Willis et al., 2009 |
| Wheat sprout        | Cronobacter sakazakii             | Czech Republic                                | Hochel et al., 2012 |
| 31 Nuts and nuts products | Almond                           | Pseudomonas aeruginosa, Klebsiella pneumoniae, Salmonella spp., Salmonella Muenchen, Salmonella Typhimurium, Salmonella Enteritidis, Salmonella Newport | Libya, USA                    | Ghenghesh et al., 2005; Lamberti et al., 2012; Bansal et al., 2010; Danyluk et al., 2006 |
|                      | Almond kernel                     | Salmonella spp.                               | USA               | Bansal et al., 2010          |
|                      | Brazil nut                        | Salmonella spp.                               | United Kingdom    | Little et al., 2010          |
|                      | Inshell almond                    | Salmonella spp.                               | USA               | Bansal et al., 2010          |
|                      | Mixed nuts                        | Salmonella spp., Listeria monocytogenes       | United Kingdom, Australia | Little et al., 2010; Eglezos 2010b |
|                      | Nuts                              | Salmonella spp., Cronobacter sakazakii, Salmonella spp. | Australia, Slovakia, United Kingdom | Eglezos et al., 2008; Turcovský et al., 2011; Little et al., 2009 |
|                      | Pistachios                        | Salmonella spp.                               | United Kingdom    | Little et al., 2009          |
|                      | Raw almond                        | Salmonella spp.                               | Australia         | Eglezos et al., 2008         |
| 32 Spices and dry powdered herbs | Anise                             | Cronobacter spp.                              | Jordan            | Jaradat et al., 2009         |
|                      | Basil                             | Cronobacter sakazakii/Cronobacter muytjensi   | Czech Republic    | Hochel et al., 2012          |
|                      | Black pepper                      | Salmonella spp., Salmonella Enterica          | Brazil, Japan     | Moreira et al., 2009; Harakudo et al., 2006 |
|                      | Black pepper powder               | Salmonella Bredene                            | Turkey            | Erol et al., 2009            |
|                      | Caraway                           | Cronobacter sakazakii                         | Czech Republic    | Hochel et al., 2012          |
|                      | Chamomile                         | Clostridium botulinum, Cronobacter spp.       | Argentina, Jordan | Bianco et al., 2008; Jaradat et al., 2009 |
|                      | Cumin                             | Salmonella spp.                               | Brazil            | Moreira et al., 2009         |
| FoNAO Category | Food item            | Pathogen                        | Country               | Reference(s)                  |
|----------------|----------------------|---------------------------------|-----------------------|-------------------------------|
|                | Curry                | *Salmonella* spp.               | Netherlands           | ECDC, 2009                    |
|                | Dried red pepper     | *Bacillus cereus*               | Korea                 | Choo et al., 2007             |
|                | Dried spices         | *Cronobacter* spp.              | Netherlands           | Kandhai et al., 2010          |
|                | Fennel               | *Cronobacter* spp.              | Jordan                | Jaradat et al., 2009          |
|                | Ginger               | *Cronobacter sakazakii/Cronobacter malonaticus* | Czech Republic | Hochel et al., 2012 |
|                | Ground red pepper    | *Salmonella Agona*              | Turkey                | Erol et al., 2009             |
|                | Herbs                | *Bacillus cereus, Clostridium perfringens, Shigella sonnei, Staphylococcus aureus, Shigella spp., Bacillus cereus, Cronobacter sakazakii, Salmonella spp, Clostridium perfringens* | Italy, Spain, United Kingdom | Vitullo et al., 2011; Sospedra et al., 2010; Sagoo et al., 2009 |
|                | Herbs and spices     | *Cronobacter spp., Cronobacter sakazakii, Cronobacter spp.* | Jordan, United Kingdom, Korea | Jaradat et al., 2009; Iversen and Forsythe, 2004; Chon et al., 2012 |
|                | Linden flower (Tilia spp.) | *Clostridium botulinum* | Argentina           | Bianco et al., 2009          |
|                | Liquorice            | *Cronobacter* spp.              | Jordan                | Jaradat et al., 2009          |
|                | Majoram              | *Cronobacter sakazakii/Cronobacter muytjenisi* | Czech Republic | Hochel et al., 2012 |
|                | Mixed Spices         | *Cronobacter* spp.              | Jordan                | Jaradat et al., 2009          |
|                | Pepper               | *Cronobacter sakazakii*         | Czech Republic        | Hochel et al., 2012          |
|                | Pimiento             | *Cronobacter malonaticus*       | Czech Republic        | Hochel et al., 2012          |
|                | Red pepper           | *Salmonella Enterica*           | Japan                 | Hara-Kudo et al., 2006        |
|                | Red pepper powder    | *Bacillus cereus, Salmonella Kentucky* | Korea, Turkey | Oh et al., 2012; Erol et al., 2009 |
|                | Saffron              | *Clostridium perfringens, Clostridium perfringens, Bacillus cereus* | Spain                | Cosano et al., 2009          |
|                | Sage                 | *Cronobacter* spp.              | Jordan                | Jaradat et al., 2009          |
| FoNAO Category | Food item | Pathogen | Country | Reference(s) |
|----------------|-----------|----------|---------|--------------|
| **Spices**     |           | *Clostridium perfringens, Bacillus cereus, Shigella spp., Staphylococcus aureus, Clostridium perfringens, Enterobacter cloacae, Bacillus cereus, Salmonella spp., Enterobacter gergoviae, Salmonella spp., Cronobacter sakazakii/Cronobacter malonaticus/Cronobacter mujtjenisi, Salmonella spp.* | United Kingdom, India, Spain, Argentina, Netherlands, Slovakia | Sagoo et al., 2009; Banerjee et al., 2003; Sospedra et al., 2010; Little et al., 2003; Aguiler et al., 2005; ECDC, 2009; Mankee et al., 2005; Turcovský et al., 2011 |
| Spices and dried herbs | Cronobacter spp. | Ireland | Baumgartner et al., 2009 |
| Spices and herbs | *Salmonella spp., Salmonella Enteritidis, Salmonella Typhimurium, Salmonella Bredeney, Listeria monocytogenes, Salmonella spp.* | United Kingdom, Netherlands, Slovakia, Italy, Hungary, Sweden | ECDC, 2009; ECDC, 2008 |
| Thyme | Cronobacter spp. | Jordan | Jaradat et al., 2009 |
| **Beverages** | Chocolate | *Salmonella Infantis, Staphylococcal enterotoxins* | Hungary, Luxembourg | ECDC, 2008, ECDC, 2009 |
| Chocolate products | *Cronobacter sakazakii/Cronobacter malonaticus* | Slovakia | Turcovský et al., 2011 |
| Ground roasted coffee beans | *Bacillus cereus* | Brazil | Chaves et al., 2012 |
| Herbal tea | *Cronobacter sakazakii* | Serbia | Stojanovic et al., 2011 |
| Ice coffee (beverage) | *Staphylococcus aureus* | Thailand | Chomvarin et al., 2006 |
| Sous | *Cronobacter sakazakii, Salmonella spp., Pseudomonas aeruginosa* | Jordan | Nassereddin and Yamani, 2005 |
| Tamarind | *Klebsiella pneumoinea, Salmonella spp.* | Jordan | Nassereddin and Yamani, 2005 |
| Tea | *Cronobacter sakazakii* | Slovakia | Turcovský et al., 2011 |
| **Other processed products, sauces and dressings, purées, soup, and pastes (including canned and bottled products)** | Aroma, sauce and gravy | *Clostridium botulinum* | France | Carlin et al., 2004 |
| Halvah | *Salmonella spp.* | Germany | Brockmann et al., 2004 |
| Instant lentil soup | *Cronobacter sakazakii/Cronobacter malonaticus* | Czech Republic | Hochel et al., 2012 |
| Instant soups | *Cronobacter malonaticus/Cronobacter dublinensis* | Slovakia | Turcovský et al., 2011 |
| Other food | *Bacillus cereus, Salmonella spp., Staphylococcus aureus* | India | Roy et al., 2007 |
| FoNAO Category | Food item | Pathogen | Country | Reference(s) |
|---------------|-----------|----------|---------|--------------|
|               | Ready to eat food | *Bacillus cereus* | United Kingdom | Little et al., 2003 |
|               | Rice soup (Infant food) | *Bacillus cereus* | Korea | Kim et al., 2011a |
|               | Sesam paste | *Salmonella* spp. | Germany | Brockmann et al., 2004 |
|               | Tarhana | *Bacillus cereus, Clostridium perfringens* | Turkey | Ucar et al., 2011; Segun et al., 2012 |
|               | Thickening agents | *Clostridium botulinum* | France | Carlin et al., 2004 |
|               | Tofu | *Cronobacter sakazakii/Cronobacter dublinensis* | Czech Republic | Hochel et al., 2012 |
| 39 Others     | Foodstuffs intended for special nutritional uses (dried dietary foods for special medical purposes intended for infants below 6 months) | *Cronobacter sakazakii* | Germany | ECDC, 2008 |
| 27/31 38 Other dry legumes, cereals, edible seeds and grains, flours and products thereof (processed products)/Nuts and nut products/Dehydrated vegetables and fruit | Dry food ingredients other than herbs and spices (nuts, fruit, grains) | *Cronobacter sakazakii* | United Kingdom | Iversen and Forsythe, 2004 |
| 28/16 15 Seeds for sprouting and sprouted seeds/ Fresh herbs/ Leafy greens eaten raw as salads | Sprouts/fresh herbs/salads | *Cronobacter spp.* | Ireland | Baumgartner et al., 2009 |
| 31/38 Nuts and nuts products/Dehydrated vegetables and fruit | Dried fruits (walnut, hazelnut, pine-nut, sultana, apricot) | *Listeria monocytogenes* | Portugal | Mena et al., 2004 |
| 32/38 Spices and dry powdered herbs/Dehydrated vegetables and fruits | Dried vegetables and spices | *Cronobacter sakazakii* | USA | Restaino et al., 2006 |

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Table 21: Categories and items of FoNAO with low water content as reported in association with parasites.

| FoNAO Category                  | Food item         | Pathogen                  | Country                     | Reference(s)        |
|---------------------------------|-------------------|---------------------------|-----------------------------|---------------------|
| **28 Seeds for sprouting and sprouted seeds** | Mung bean sprouts | Cryptosporidium spp., Giardia spp. | Norway                      | Robertson et al., 2002 |
|                                 | Mung bean sprouts | Enterocytozoon bieneusi, Cryptosporidium spp., Giardia spp. | Poland, USA, Norway, Canada | Jedrzejewski et al., 2007; Robertson et al., 2005 |
|                                 | Radish sprouts    | Giardia spp.              | Norway                      | Robertson et al., 2002 |
|                                 | Sprouts           | Microsporidian spores     | Poland, USA                 | Jedrzejewski et al., 2007 |

Table 22: Critical points in specific primary production procedures reported for the food items listed in Tables 20 and 21.

| Food item | FoNAO category | Critical point | Pathogen" | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|------------|---------|-----------|--------------|
| Baby corn | 24             | harvesting     | n.r.       | Thailand| non-EU    | Soylemez et al., 2001 |
|           |                |                | n.r.       | Thailand| non-EU    | CDC, 2009    |
|           |                |                | n.r.       | Italy   | EU        | CDC, 2009    |
|           |                | environment    | n.r.       | Italy   | EU        | CDC, 2009    |
|           |                | manure         | n.r.       | Italy   | EU        | Lampinen et al., 2004 |
|           |                | personnel      | n.r.       | Italy   | EU        | Lampinen et al., 2004 |
|           |                | water          | n.r.       | Italy   | EU        | Lampinen et al., 2004 |
|          |                |                |            |         |           |              |
| Cereals   | 24             | harvesting     | Salmonella spp. | New Zealand| non-EU    | Anonymous, 2006 |
|          |                | cultivation    | Salmonella spp. | New Zealand| non-EU    | Anonymous, 2006 |
|          |                | transport      | Salmonella spp. | New Zealand| non-EU    | FAO, 2010    |
| Seed      |                | fecal matter   | Salmonella spp. | USA       | non-EU    | FAO, 2010    |
|          |                | Campylobacter  | USA         | non-EU   | FAO, 2010    |

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| Food item                      | FoNAO category | Critical point | Pathogen | Country   | EU/non-EU | Reference(s) |
|-------------------------------|----------------|----------------|----------|-----------|-----------|--------------|
| Alfalfa Seeds and Sprouts     | 28             | manure         | *Escherichia coli* | USA       | non-EU    | FAO, 2010    |
|                               |                | water          | *Cryptosporidium* | USA       | non-EU    | UVM, 2011    |
|                               |                | fecal matter   | n.r.      | USA       | non-EU    | Aarathi et al., 2012 |
|                               |                | harvesting     | n.r.      | USA       | non-EU    | MGU, 2010    |
|                               |                | irrigation     | n.r.      | USA       | non-EU    | TAS, 2005    |
|                               |                | manure         | n.r.      | USA       | non-EU    | TAS, 2005    |
| Linseed                       | 28             | cultivation    | n.r.      | Finland   | EU        | TAS, 2005    |
|                               |                | harvesting     | n.r.      | Finland   | EU        | TAS, 2005    |
| Ready-To-Eat Dried Seeds      | 28             | irrigation     | *Salmonella spp.* | United Kingdom   | EU        | IPC, 2007    |
|                               |                | manure         | *Salmonella spp.* | United Kingdom   | EU        | IPC, 2007    |
|                               |                | soil           | *Salmonella spp.* | United Kingdom   | EU        | IPC, 2007    |
|                               |                | fecal matter   | *Salmonella spp.* | United Kingdom   | EU        | IPC, 2007    |
| Seeds for sprouting           | 28             | cleaning       | *Escherichia coli* | Australia | non-EU    | Warriner, s.a. |
|                               |                | n.r.           | *Listeria spp.* | Australia | non-EU    | ARS, 2000    |
|                               |                | n.r.           | *Salmonella spp.* | Australia | non-EU    | ARS, 2000    |
|                               |                | cultivation    | n.r.      | EU        | EU        | Peter, 2004  |
|                               |                | n.r.           | USA       | non-EU    | Stankovic et al., 2006 |
|                               |                | n.r.           | USA       | non-EU    | FSANZ, 2012 |
|                               |                | equipment      | n.r.      | Canada    | non-EU    | NZFSA, 2010b |
|                               |                | fecal matter   | *Escherichia coli* | Australia | non-EU    | ARS, 2000    |
|                               |                |                | *Escherichia coli* | Canada    | non-EU    | HPA, s.a.    |
### Food of plant origin with low water content

| Food item | FoNAO category | Critical point | Pathogen | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------|---------|----------|--------------|
|           |                |                | **Escherichia coli** | USA     | non-EU   | FSANZ, 2012 |
|           |                |                | **Escherichia coli** | USA     | non-EU   | FSN,2000     |
|           |                |                | **Listeria spp.**  | Australia | non-EU   | ARS, 2000    |
|           |                |                | **Listeria spp.**  | USA     | non-EU   | FSN,2000     |
|           |                |                | n.r.            | Canada  | non-EU   | NZFSA, 2010b |
|           |                |                | n.r.            | Canada  | non-EU   | FSN,2000     |
|           |                |                | n.r.            | EU      | EU       | UNIDO, 2005  |
|           |                |                | n.r.            | Japan   | non-EU   | EC, 2004     |
|           |                |                | n.r.            | United Kingdom | EU      | FAO, 2012    |
|           |                |                | n.r.            | USA     | non-EU   | Warriner, s.a. |
|           |                | harvesting     | **Salmonella spp.** | Australia | non-EU   | Bari et al., 2011a |
|           |                |                | **Salmonella spp.** | Canada  | non-EU   | HPA, s.a.    |
|           |                |                | **Salmonella spp.** | USA     | non-EU   | EC, 2004     |
|           |                |                | n.r.            | USA     | non-EU   | FSANZ, 2012  |
|           |                |                | n.r.            | Australia | non-EU   | Bari et al., 2011a |
|           |                |                | n.r.            | Australia New Zealand | non-EU   | FAO, 2012 |
|           |                |                | n.r.            | Canada  | non-EU   | HPA, s.a.    |
|           |                |                | n.r.            | EU      | EU       | Koivula et al., 2004 |
|           |                |                | n.r.            | Italy   | EU       | FAO, 2012    |
|           |                |                | n.r.            | Japan   | non-EU   | EC, 2004     |
|           |                |                | n.r.            | Malaysia | non-EU   | Schrader, 2002 |
|           |                |                | n.r.            | USA     | non-EU   | FSANZ, 2012  |
|           |                |                | **Salmonella spp.** | Australia | non-EU   | Bari et al., 2011a |

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| Food item | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------------|---------|-----------|--------------|
|          |                | irrigation     | *Salmonella* spp.| USA     | non-EU    | EC, 2004     |
|          |                | n.r.           | *Salmonella* spp.| Australia New Zealand | non-EU | FAO, 2012  |
|          |                | n.r.           | *Escherichia coli* | Canada | non-EU | NZFSA, 2010b |
|          |                | n.r.           | *Escherichia coli* | Canada | non-EU | FSN, 2000 |
|          |                | n.r.           | *Escherichia coli* | Italy | EU | FAO, 2012 |
|          |                | n.r.           | *Escherichia coli* | Philippines | non-EU | CFS, 2011 |
|          |                | n.r.           | *Escherichia coli* | United Kingdom | EU | FAO, 2012 |
|          |                | n.r.           | *Escherichia coli* | USA | non-EU | FSN, 2000 |
|          |                | manure         | *Salmonella* spp.| USA | non-EU | EC, 2004 |
|          |                | n.r.           | *Salmonella* spp.| Canada | non-EU | Schrader, 2002 |
|          |                | n.r.           | *Escherichia coli* | Australia New Zealand | non-EU | NSW Food Authority, 2012 |
|          |                | n.r.           | *Escherichia coli* | Canada | non-EU | NZFSA, 2010b |
|          |                | n.r.           | *Escherichia coli* | Italy | EU | FAO, 2012 |
|          |                | n.r.           | *Escherichia coli* | Malaysia | non-EU | Warriner, s.a. |
|          |                | n.r.           | *Escherichia coli* | Philippines | non-EU | Schrader, 2002 |
|          |                | n.r.           | *Escherichia coli* | United Kingdom | EU | FAO, 2012 |
|          |                | n.r.           | *Escherichia coli* | USA | non-EU | FSN, 2000 |
|          |                | packaging      | *Salmonella* spp.| USA | non-EU | EC, 2004 |
|          |                | n.r.           | *Escherichia coli* | Australia | non-EU | EFSA, 2011, online |
|          |                | n.r.           | *Listeria* spp. | Australia | non-EU | EFSA, 2011, online |
|          |                | n.r.           | *Salmonella* spp.| USA | non-EU | Stankovic et al., 2006 |
|          |                | n.r.           | *Escherichia coli* | Australia | non-EU | EFSA, 2011, online |

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| Food item | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------------|---------|-----------|--------------|
|           |                | transport      | *Listeria* spp. | Australia | non-EU    | FAOWHO_2011  |
|           |                |                | *Salmonella* spp. | Australia | non-EU    | FAOWHO_2011  |
|           |                | water          | *Escherichia coli* | Australia | non-EU    | FAOWHO_2011  |
|           |                |                | *Listeria* spp. | Australia | non-EU    | FAOWHO_2011  |
|           |                |                | n.r.           | Australia New Zealand | non-EU    | IPC, 2012    |
|           |                |                | n.r.           | Canada    | non-EU    | CFS, 2011    |
|           |                |                | n.r.           | Italy     | EU        | FAO, 2012    |
|           |                |                | n.r.           | Japan     | non-EU    | WojcikStopczynska et al., 2009 |
|           |                |                | n.r.           | Malaysia  | non-EU    | Warriner, s.a. |
|           |                |                | *Salmonella* spp. | Australia | non-EU    | Food Standards Agency, s.a. |
|           |                |                | *Escherichia coli* | Australia | non-EU    | Food Standards Agency, s.a. |
|           |                |                | *Escherichia coli* | Canada    | non-EU    | CFS, 2011    |
|           |                |                | *Listeria* spp. | Australia | non-EU    | Food Standards Agency, s.a. |
|           |                |                | n.r.           | EU        | EU        | Koivula et al., 2004 |
|           |                |                | n.r.           | Japan     | non-EU    | WojcikStopczynska et al., 2009 |
|           |                |                | *Salmonella* spp. | Australia | non-EU    | FSANZ, 2012  |
|           |                |                | *Salmonella* spp. | Canada    | non-EU    | CFS, 2011    |
| Sesame    | 28             | cultivation    | *Salmonella* spp. | USA       | non-EU    | FSN,2000     |
|           |                | environment    | *Salmonella* spp. | USA       | non-EU    | Gabriel, 2005 |
|           |                | cleaning       | *Salmonella* spp. | USA       | non-EU    | Gabriel, 2005 |
|           |                | drying         | *Salmonella* spp. | USA       | non-EU    | Mohle-Boetani et al., 2009 |
|           |                |                | *Salmonella* spp. | USA       | non-EU    | Mustar and Nazaimoon, 2010 |
|           |                |                | *Salmonella* spp. | USA       | non-EU    | Mustar and Nazaimoon, 2010 |
| Food item | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------------|---------|----------|--------------|
| Almond    | 31             | harvesting     | *Salmonella* spp. | USA     | non-EU   | Mustar and Nazaimoon, 2010 |
|           |                | personnel      | *Salmonella* spp. | USA     | non-EU   | NSW Food Authority, s.a. |
|           |                | manure         | *Salmonella* spp. | USA     | non-EU   | NSW Food Authority, s.a. |
|           |                | storage        | *Salmonella* spp. | USA     | non-EU   | NSW Food Authority, s.a. |
|           |                | water          | *Salmonella* spp. | USA     | non-EU   | NSW Food Authority, s.a. |
|           |                | fecal matter   | *Salmonella* spp. | New Zealand | non-EU | NSW Food Authority, s.a. |
|           |                | water          | *Salmonella* spp. | New Zealand | non-EU | NSW Food Authority, s.a. |
|           |                | harvesting     | *Salmonella* spp. | USA     | non-EU   | NSW Food Authority, s.a. |
| Nuts      | 31             | fecal matter   | *Salmonella* spp. | Italy   | EU       | NSW Food Authority, s.a. |
|           |                | irrigation     | *Salmonella* spp. | Italy   | EU       | NSW Food Authority, s.a. |
|           |                | harvesting     | *Salmonella* spp. | Italy   | EU       | NSW Food Authority, s.a. |
|           |                |                | *Escherichia coli* | Italy   | EU       | NSW Food Authority, s.a. |
|           |                |                | *Salmonella* spp. | Australia | non-EU | NSW Food Authority, s.a. |
| Black pepper | 32         | cultivation   | n.r.           | Indonesia | non-EU | FD, 2006 |

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| Food item | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------------|---------|----------|--------------|
| n.r.      | Indonesia      | n.r.           | AIV, s.a.      |         |          |              |
| environment | n.r.           | Thailand       | non-EU         | Buck et al., 2003 |
| n.r.      | Indonesia      | n.r.           | FD, 2006       |         |          |              |
| fecal matter | n.r.       | Thailand       | non-EU         | Buck et al., 2003 |
| harvesting | n.r.           | India          | non-EU         | Taormina et al., 1999 |
| n.r.      | Thailand       | n.r.           | non-EU         | Buck et al., 2003 |
| manure    | n.r.           | Indonesia      | non-EU         | ASTA, 2011 |
| soil      | n.r.           | Indonesia      | non-EU         | Buck et al., 2003 |
| water     | n.r.           | Thailand       | non-EU         | Buck et al., 2003 |
| n.r.      | Indonesia      | n.r.           | ASTA, 2011     |         |          |              |
| Cayenne pepper | 32           | n.r.           | Proteus ssp.   | Serbia  | non-EU   | ASTA, 2011 |
|           |                |                | Escherichia coli | Serbia  | non-EU   | ASTA, 2011 |
| Herbs     | 32             | cultivation    | n.r.           | EU      | EU       | ASTA, 2011 |
|           |                |                | n.r.           | Poland  | EU       | ASTA, 2011 |
|          |                | environment    | n.r.           | EU      | EU       | ASTA, 2011 |
|          |                | fecal matter   | n.r.           | EU      | EU       | ASTA, 2011 |
|          |                | harvesting     | n.r.           | EU      | EU       | ASTA, 2011 |
|          |                |                | n.r.           | Poland  | EU       | ASTA, 2011 |
|          |                |                | n.r.           | non-EU  | non-EU   | NZFSA, 2010 |
| Pepper   | 32             | harvesting     | n.r.           | Indonesia | non-EU | NZFSA, 2010 |

\(^a\) The presence of one or more of these pathogens in the critical point is of concern.
| Food item | FoNAO category | Critical point | Pathogen<sup>a</sup> | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------------------|---------|-----------|--------------|
| Spices    | 32             | cultivation    | n.r.                 | EU      | EU        | USAID, 2009  |
|           |                |                | n.r.                 | Serbia  | non-EU    | SBI, 2012    |
|           |                |                | n.r.                 | Pakistan| non-EU    | UNIDO, 2005  |
|           |                | environment    | n.r.                 | EU      | EU        | EC, 2004     |
|           |                |                | n.r.                 | India   | non-EU    | EC, 2004     |
|           |                |                | n.r.                 | Brasil  | non-EU    | Stankovic et al., 2006 |
|           |                |                | n.r.                 | Turkey  | non-EU    | das Chagas Oliveira Freire and Offord, 2002 |
| fecal matter | n.r.             | harvesting    | n.r.                 | EU      | EU        | EC, 2004     |
|           |                |                | n.r.                 | Brasil  | non-EU    | das Chagas Oliveira Freire and Offord, 2002 |
|           |                |                | n.r.                 | Turkey  | non-EU    | Hampikyan et al., 2009 |
|           |                |                | n.r.                 | non-EU  | non-EU    | Hampikyan et al., 2009 |
|           |                |                | n.r.                 | Pakistan| non-EU    | HEC, 2009    |
| packaging | n.r.             | packaging      | n.r.                 | India   | non-EU    | SBI, 2012    |
| personnel | n.r.             | personnel      | n.r.                 | EU      | EU        | EC, 2004     |
|           |                |                | n.r.                 | India   | non-EU    | SBI, 2012    |
|           |                |                | n.r.                 | Brasil  | non-EU    | das Chagas Oliveira Freire and Offord, 2002 |
| processing| n.r.             | processing     | n.r.                 | India   | non-EU    | SBI, 2012    |
| storage   | n.r.             | storage        | n.r.                 | India   | non-EU    | SBI, 2012    |
| water     | n.r.             | water          | n.r.                 | EU      | EU        | EC, 2004     |
| Beans     | 37             | soil           | n.r.                 | USA     | non-EU    | HEC, 2009    |

<sup>a</sup>n.r. = not reported concerning a specific pathogen
### Table 23: Critical points in specific processing procedures reported for the food items listed in Tables 20 and 21.

| Food item | FoNAO category | Critical point | Pathogen* | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------|---------|-----------|--------------|
| Baby corn | 24             | cleaning       | n.r.      | Australia | non-EU    | Anonymous, 2006 |
|           |                | heating        | n.r.      | Australia | non-EU    | Anonymous, 2006 |
|           |                | packaging      | n.r.      | Thailand | non-EU    | Liu et al., 2007 |
|           |                |               | n.r.      | China    | non-EU    | Anonymous, 2006 |
|           |                | processing     | n.r.      | China    | non-EU    | AQIS, 2005    |
|           |                | raw material   | n.r.      | China    | non-EU    | AQIS, 2005    |
|           |                | storage        | n.r.      | Thailand | non-EU    | Soylemez et al., 2001 |
|           |                |               | n.r.      | Thailand | non-EU    | ACFS, 2005    |
|           |                | transport      | n.r.      | Thailand | non-EU    | Liu et al., 2007 |
|           |                |               | n.r.      | Thailand | non-EU    | ACFS, 2005    |
|           |                | water          | n.r.      | Thailand | non-EU    | ACFS, 2005    |
|           |                | heating        |          | USA      | non-EU    | STR, 2005    |
|           |                | milling        | n.r.      | USA      | non-EU    | STR, 2005    |
|           |                |                |           | Salmonella spp. | New Zealand | non-EU    | FSSAI, 2010 |
|           |                |                |           | Salmonella spp. | New Zealand | non-EU    | FSSAI, 2010 |
| Cereals   | 24             | raw material   | Salmonella spp. | New Zealand | non-EU    | FSSAI, 2010 |
|           |                | storage        | n.r.      | USA      | non-EU    | STR, 2005    |
|           |                |                |           | Salmonella spp. | New Zealand | non-EU    | FSSAI, 2010 |
| Wheat     | 24             | milling        | n.r.      | Canada   | non-EU    | FSSAI, 2010 |
|           |                | packaging      | n.r.      | Canada   | non-EU    | FSSAI, 2010 |
| Food item            | FoNAO category | Critical point | Pathogen\(^a\) | Country       | EU/non-EU | Reference(s)          |
|---------------------|----------------|----------------|----------------|---------------|-----------|------------------------|
| processing          | n.r.           |                |                | Canada        | non-EU    | FSSAI, 2010            |
| receiving           | n.r.           |                |                | Canada        | non-EU    | FSSAI, 2010            |
| storage             | n.r.           |                |                | USA           | non-EU    | ICMSF, 1986            |
| Rice                | 25             | cleaning       | n.r.           | United Kingdom| EU        | NSW Food Authority, 2009b |
|                     |                | drying         | n.r.           | United Kingdom| non-EU    | NSW Food Authority, 2009b |
|                     |                | equipment      | n.r.           | United Kingdom| EU        | NSW Food Authority, 2009b |
|                     |                | heating        | n.r.           | United Kingdom| EU        | NSW Food Authority, 2009b |
|                     |                | personnel      | n.r.           | United Kingdom| EU        | NSW Food Authority, 2009b |
|                     |                | raw material   | n.r.           | United Kingdom| EU        | NSW Food Authority, 2009c |
|                     |                | storage        | n.r.           | United Kingdom| EU        | UNIDO, 2004            |
|                     |                | water          | n.r.           | United Kingdom| EU        | UNIDO, 2004            |
| Bakery products     | 27             | cleaning       | n.r.           | India         | non-EU    | UNIDO, 2004            |
|                     |                |                | n.r.           | Australia     | non-EU    | Aarathi et al., 2012   |
|                     |                |                | n.r.           | Austria       | EU        | Aarathi et al., 2012   |
|                     |                | environment    | n.r.           | India         | non-EU    | UNIDO, 2004            |
|                     |                |                | n.r.           | Austria       | EU        | EIA, 2002              |
|                     |                | equipment      | n.r.           | India         | non-EU    | UNIDO, 2004            |
|                     |                |                | n.r.           | Australia     | non-EU    | Aarathi et al., 2012   |
|                     |                |                | n.r.           | Austria       | EU        | EIA, 2002              |
|                     |                | packaging      | n.r.           | India         | non-EU    | UNIDO, 2004            |
|                     |                |                | n.r.           | Austria       | EU        | EIA, 2002              |
|                     |                | personnel      | n.r.           | India         | non-EU    | Ciat, 1999             |

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| Food item                  | FoNAO category | Critical point | Pathogen\(^a\) | Country   | EU/non-EU | Reference(s)                  |
|---------------------------|----------------|----------------|----------------|-----------|-----------|-------------------------------|
| processing                | n.r.           | Australia      | non-EU         | Aarathi et al., 2012 |
| raw material              | n.r.           | India          | non-EU         | DAFF, 2010 |
| storage                   | n.r.           | Australia      | non-EU         | Aarathi et al., 2012 |
| water                     | n.r.           | Austria        | EU             | EIA, 2002  |
| Flour                     | 27             | cleaning       | n.r.           | Greece    | EU        | EIA, 2002                     |
|                           |                | packaging      | n.r.           | Greece    | EU        | EIA, 2002                     |
|                           |                | raw material   | n.r.           | Greece    | EU        | IPC, 2012                      |
|                           |                | storage        | n.r.           | Greece    | EU        | Joy et al., 2002              |
|                           |                | water          | n.r.           | Greece    | EU        | MGU, 2010                     |
| Alfalfa Seeds and Sprouts | 28             | water          | n.r.           | USA       | non-EU    | MGU, 2010                     |
| Alfalfa Sprouts           | 28             | water          | n.r.           | USA       | non-EU    | Peter, 2001                   |
| Linseed                   | 28             | cleaning       | Escherichia coli | United Kingdom | EU | Martinez-Villaluenga et al., 2008 |
|                           |                | Salmonella spp. | United Kingdom | EU | Martinez-Villaluenga et al., 2008 |
|                           |                | drying         | Escherichia coli | United Kingdom | EU | Martinez-Villaluenga et al., 2008 |
|                           |                | Salmonella spp. | United Kingdom | EU | Martinez-Villaluenga et al., 2008 |
| Ready-To-Eat Dried Seeds  | 28             | drying         | Salmonella spp. | United Kingdom | EU | FRI, 2007                     |
|                           |                | heating        | Salmonella spp. | United Kingdom | EU | FRI, 2007                     |
| Seeds for                 | 28             | storage        | n.r.           | Japan      | non-EU    | FRI, 2007                     |
| Food item     | FoNAO category | Critical point | Pathogen | Country | EU/non-EU | Reference(s) |
|--------------|----------------|----------------|----------|---------|-----------|--------------|
| sprouting    |                | n.r.           | USA      | non-EU  | ADM, 2009 |              |
|              |                | *Salmonella* spp. | USA      | non-EU  | Cordier, 1994 |              |
|              |                | n.r.           | Malaysia | non-EU  | Cordier, 1994 |              |
|              |                | *Escherichia coli* | Australia | non-EU  | Cordier, 1994 |              |
|              |                | *Listeria* spp. | Australia | non-EU  | Cordier, 1994 |              |
| Sesame       | 28             | antimicrobial treatment | *Salmonella* spp. | USA      | non-EU  | Gilmour, 2009 |
|              |                |                | *Salmonella* spp. | USA      | non-EU  | Gilmour, 2009 |
|              |                | heating        | *Salmonella* spp. | New Zealand | non-EU  | Januszewska, 2006 |
|              |                | packaging      | *Salmonella* spp. | USA      | non-EU  | GMA, 2009 |
|              |                |                | *Salmonella* spp. | USA      | non-EU  | Januszewska, 2006 |
|              |                | personnel      | *Salmonella* spp. | USA      | non-EU  | Gilmour, 2009 |
|              |                | processing     | *Salmonella* spp. | USA      | non-EU  | Cordier, 1994 |
|              |                |                | *Salmonella* spp. | USA      | non-EU  | Januszewska, 2006 |
|              |                | storage        | *Salmonella* spp. | USA      | non-EU  | EC, 2003 |
|              |                |                | *Salmonella* spp. | USA      | non-EU  | Gilmour, 2009 |
|              |                |                | *Salmonella* spp. | USA      | non-EU  | Januszewska, 2006 |
|              |                |                | *Escherichia coli* | Germany  | EU     | Januszewska, 2006 |
|              |                |                | *Salmonella* spp. | Germany  | EU     | Januszewska, 2006 |
|              |                |                | *Staphylococcus aureus* | Germany  | EU     | Januszewska, 2006 |
|              |                | transport      | *Salmonella* spp. | USA      | non-EU  | Januszewska, 2006 |
|              |                | water          | *Salmonella* spp. | USA      | non-EU  | Gilmour, 2009 |
|              |                |                | *Salmonella* spp. | USA      | non-EU  | GMA, 2009 |

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| Food item          | FoNAO category | Critical point | Pathogen* | Country | EU/non-EU | Reference(s)          |
|-------------------|----------------|----------------|-----------|---------|-----------|-----------------------|
| Sprouts           | 28             | antimicrobial treatment | n.r.     | Canada  | non-EU    | Mermelstein, 2012     |
|                   |                | n.r.           | n.r.      | Canada  | non-EU    | Nascimento et al., 2009 |
|                   |                | n.r.           | n.r.      | Canada  | non-EU    | Mermelstein, 2012     |
|                   |                | n.r.           | n.r.      | Canada  | non-EU    | Nascimento et al., 2009 |
|                   |                | cleaning       | n.r.      | USA     | non-EU    | NCA, s.a. (b)         |
|                   |                | n.r.           | n.r.      | USA     | non-EU    | NCA, s.a. (b)         |
|                   |                | cooling        | n.r.      | Canada  | non-EU    | NCA, s.a.             |
|                   |                | n.r.           | n.r.      | Italy    | EU        | FAO, 2012             |
|                   |                | n.r.           | n.r.      | Canada  | non-EU    | NCA, s.a.             |
|                   |                | equipment      | n.r.      | India    | non-EU    | EC, 2004              |
|                   |                | n.r.           | n.r.      | India    | non-EU    | EC, 2004              |
|                   |                | fecal matter   | n.r.      | USA      | non-EU    | IPC, 2012             |
|                   |                | germination    | n.r.      | USA      | non-EU    | Januszewska, 2006     |
|                   |                | n.r.           | n.r.      | Canada  | non-EU    | Nascimento et al., 2009 |
|                   |                | n.r.           | n.r.      | Canada  | non-EU    | NCA, s.a.             |
|                   |                | Salmonella spp.| n.r.      | EU      | EU        | NCA, s.a. (b)         |
|                   |                | Bacillus cereus| n.r.      | Canada  | non-EU    | NCA, s.a. (b)         |
|                   |                | Escherichia coli| n.r.  | Japan    | non-EU    | WojcikStopczynska et al., 2009 |
|                   |                | Listeria spp.  | n.r.      | Japan    | non-EU    | WojcikStopczynska et al., 2009 |
|                   |                | Escherichia coli| n.r.  | USA      | non-EU    | FAO, 2012             |
### Food of plant origin with low water content

| Food item | FoNAO category | Critical point | Pathogen⁹ | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------|---------|-----------|--------------|
| *Salmonella* spp. |                |                | USA       | non-EU  | FAO, 2012 |
| n.r.      |                |                | Italy     | EU      | FAO, 2012 |
| n.r.      |                |                | n.r.      | EU      | GMA, 2010 |
| n.r.      |                |                | n.r.      | non-EU  | Hurst, s.a. |
| n.r.      |                |                | n.r.      | non-EU  | ABC, 2010 |
| *Campylobacter* spp. |       |                | New Zealand | non-EU | ERG, 2004 |
| *Listeria* spp. |                |                | New Zealand | non-EU | GMA, 2009 |
| *Salmonella* spp. |                |                | New Zealand | non-EU | GMA, 2009 |
| *Escherichia coli* |       |                | Australia | non-EU  | IYCN, s.a. |
| *Listeria* spp. |                |                | Australia | non-EU  | IYCN, s.a. |
| *Salmonella* spp. |                |                | Australia | non-EU  | IYCN, s.a. |
| n.r.      |                |                | USA       | non-EU  | IPC, 2012 |
| n.r.      |                |                | USA       | non-EU  | IPC, 2012 |
| n.r.      |                |                | Canada    | non-EU  | Nascimento et al., 2009 |
| n.r.      |                |                | Canada    | non-EU  | NCA, s.a. |
| *Salmonella* spp. |                |                | EU        | EU      | NCA, s.a. (b) |
| n.r.      |                |                | Canada    | non-EU  | NCA, s.a. (b) |
| harvesting |                |                | n.r.      | USA     | Januszewska, 2006 |
| harvesting |                |                | n.r.      | Canada  | NCA, s.a. (b) |
| harvesting |                |                | n.r.      | USA     | EC, 2004 |
| harvesting |                |                | n.r.      | Italy   | FAO, 2012 |
| harvesting |                |                | n.r.      | n.r.    | Little et al., s.a. |

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| Food item | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------------|---------|-----------|--------------|
| Salmonella spp. | USA | non-EU | APC, 2009 |
| Campylobacter spp. | New Zealand | non-EU | GMA, 2010 |
| Listeria spp. | New Zealand | non-EU | GMA, 2010 |
| Salmonella spp. | New Zealand | non-EU | GMA, 2010 |
| n.r.  | Canada | non-EU | NCA, s.a. (b) |
| Heating | Salmonella spp. | EU | EU | NCA, s.a. (b) |
| Salmonella spp. | EU | EU | NCA, s.a. (b) |
| Packaging | n.r.  | Canada | non-EU | Nascimento et al., 2009 |
| n.r.  | Canada | non-EU | NCA, s.a. (b) |
| Escherichia coli | USA | non-EU | FAO, 2012 |
| Salmonella spp. | USA | non-EU | FAO, 2012 |
| n.r.  | n.r.  | non-EU | ABC, 2010 |
| Salmonella spp. | USA | non-EU | APC, 2009 |
| Campylobacter spp. | New Zealand | non-EU | GMA, 2010 |
| Listeria spp. | New Zealand | non-EU | GMA, 2010 |
| Salmonella spp. | New Zealand | non-EU | GMA, 2010 |
| n.r.  | USA | non-EU | IPC, 2012 |
| n.r.  | Canada | non-EU | Nascimento et al., 2009 |
| n.r.  | Canada | non-EU | NCA, s.a. (b) |
| Personnel | n.r.  | India | non-EU | EC, 2004 |
| Escherichia coli | Germany | EU | ABC, 2010 |
| n.r.  | India | non-EU | EC, 2004 |
| Food item | FoNAO category | Critical point | Pathogen* | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------|---------|-----------|--------------|
| processing | n.r. | EU | n.r. | NCA, s.a. (b) |
| | n.r. | USA | non-EU | EC, 2004 |
| | n.r. | non-EU | ABC, 2010 |
| | Escherichia coli | Australia | non-EU | IYCN, s.a. |
| | Listeria spp. | Australia | non-EU | IYCN, s.a. |
| | Salmonella spp. | Australia | non-EU | IYCN, s.a. |
| | n.r. | EU | n.r. | NCA, s.a. (b) |
| raw material | n.r. | Canada | n.r. | Januszewska, 2006 |
| | n.r. | USA | non-EU | NCA, s.a. (b) |
| | n.r. | Canada | non-EU | Arvanitoyan-nis and Trai-kou, 2005 |
| | n.r. | USA | non-EU | UNIDO, 2005 |
| | n.r. | Netherlands | EU | UNIDO, 2005 |
| | Escherichia coli | Germany | EU | ABC, 2010 |
| | n.r. | USA | non-EU | ABC, 2010 |
| | n.r. | EU | n.r. | ABC, 2010 |
| | n.r. | Italy | EU | FAO, 2012 |
| | n.r. | n.r. | EU | GMA, 2010 |
| | n.r. | non-EU | Little et al., s.a. |
| | Salmonella spp. | USA | non-EU | ERG, 2004 |
| | Listeria spp. | New Zealand | non-EU | GMA, 2010 |
| | Salmonella spp. | New Zealand | non-EU | IYCN, s.a. |
| | Escherichia coli | Australia | non-EU | MAF VS, s.a. |
| Food item | FoNAO category | Critical point | Pathogen⁶ | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------|---------|-----------|--------------|
| Listeria spp. | Australia | non-EU | MAF VS, s.a. |
| Salmonella spp. | Australia | non-EU | CFS, 2011 |
| n.r. | India | non-EU | IPC, 2012 |
| n.r. | USA | non-EU | NCA, s.a. (b) |
| n.r. | Canada | non-EU | Arvanitoyannis and Traikou, 2005 |
| receiving | n.r. | USA | non-EU | IPC, 2012 |
| storage | n.r. | Canada | non-EU | Kačániová and Juhaniaková, 2011 |
| Salmonella spp. | EU | EU | NCA, s.a. (b) |
| n.r. | Canada | non-EU | NCA, s.a. (b) |
| n.r. | USA | non-EU | NCA, s.a. (b) |
| n.r. | EU | EU | NCA, s.a. (b) |
| n.r. | USA | non-EU | Arvanitoyannis and Traikou, 2005 |
| n.r. | USA | non-EU | UNIDO, 2005 |
| n.r. | EU | EU | GMA, 2010 |
| n.r. | n.r. | non-EU | Little et al., s.a. |
| n.r. | Canada | non-EU | Kačániová and Juhaniaková, 2011 |
| Salmonella spp. | EU | EU | NCA, s.a. (b) |
| n.r. | Canada | non-EU | NCA, s.a. (b) |
| n.r. | USA | non-EU | NCA, s.a. (b) |
| n.r. | EU | EU | NCA, s.a. (b) |
| n.r. | USA | non-EU | Arvanitoyannis and Traikou, 2005 |
| transport | n.r. | USA | non-EU | Januszewska, 2006 |

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| Food item | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------------|---------|-----------|--------------|
| n.r.      | n.r.           | Canada         | non-EU         | Kačáňiová and Juhaniaková, 2011 |
| n.r.      | n.r.           | Canada         | non-EU         | NCA, s.a. (b) |
| n.r.      | n.r.           | EU             | EU             | Arvanitoyan-nis and Traikou, 2005 |
| *Escherichia coli* | USA         | non-EU         | FAO, 2012     |
| *Salmonella* spp. | USA | non-EU         | FAO, 2012     |
| n.r.      | n.r.           | Canada         | non-EU         | Kačáňiová and Juhaniaková, 2011 |
| n.r.      | n.r.           | Canada         | non-EU         | NCA, s.a. (b) |
| n.r.      | n.r.           | EU             | EU             | Arvanitoyannis and Traikou, 2005 |
| *Escherichia coli* | Canada     | EU             | EU             | Kačáňiová and Juhaniaková, 2011 |
| n.r.      | n.r.           | Canada         | non-EU         | Nascimento et al., 2009 |
| n.r.      | n.r.           | Canada         | non-EU         | Arvanitoyan-nis and Traikou, 2005 |
| n.r.      | n.r.           | USA            | non-EU         | Arvanitoyan-nis and Traikou, 2005 |
| n.r.      | n.r.           | Canada         | non-EU         | EC, 2004 |
| *Escherichia coli* | Germany     | EU             | ABC, 2010     |
| n.r.      | n.r.           | EU             | EU             | FAO, 2012 |
| n.r.      | n.r.           | n.r.           | EU             | Hurst, s.a. |
| n.r.      | n.r.           | n.r.           | non-EU         | NSW Food Authority, 2012 |
| n.r.      | n.r.           | n.r.           | non-EU         | NSW Food Authority, 2012 |
| *Salmonella* spp. | USA         | non-EU         | ERG, 2004     |
| *Campylobacter* spp. | New Zealand | non-EU         | IYCN, s.a.    |
| *Listeria* spp. | New Zealand | non-EU         | IYCN, s.a.    |
| Food item | FoNAO category | Critical point | Pathogen | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------|---------|-----------|--------------|
| Nuts | | antimicrobial treatment | n.r. | Italy | EU | WARDA, 2010 |
| | | cleaning | Escherichia coli | Italy | EU | WarwickDC, s.a. |
| | | heating | Salmonella spp. | Italy | EU | WarwickDC, s.a. |
| | | personnel | n.r. | USA | non-EU | IPCC, 2012 |
| | | processing | Salmonella spp. | USA | non-EU | FSANZ, 2012 |
| | | processing | n.r. | United Kingdom | EU | NSW Food Authority, s.a. |
| | | raw material | Salmonella spp. | USA | non-EU | FSN, 2000 |
| | | receiving | Salmonella spp. | USA | non-EU | Mohle-Boetani et al., 2009 |
| | | segregation | n.r. | Italy | EU | WarwickDC, s.a. |
| | | shelling | Salmonella spp. | Italy | EU | WarwickDC, s.a. |
| | | shelling | Salmonella spp. | USA | non-EU | Mustar and Nazaimoon, 2010 |
| | | shelling | n.r. | United Kingdom | EU | NSW Food Authority, s.a. |
| Food item       | FoNAO category | Critical point | Pathogen¹ | Country | EU/non-EU | Reference(s) |
|----------------|----------------|----------------|-----------|---------|-----------|--------------|
| shelling       | n.r.           | Australia      | non-EU    | AIV, 2010|
| storage        | *Salmonella* ssp. | Italy          | EU        | WarwickDC, s.a. |
| storage        | n.r.           | Italy          | EU        | Bari et al., 2011a |
| storage        | n.r.           | USA            | non-EU    | HDHHS., s.a. |
| storage        | *Salmonella* ssp. | USA            | non-EU    | NSW Food Authority, s.a. |
| storage        | n.r.           | United Kingdom | EU        | AIV, 2010 |
| storage        | *Salmonella* ssp. | Australia      | non-EU    | ASTA, 2011 |
| water          | *Escherichia coli* | Italy          | EU        | EFSA, 2011, online |
| water          | *Salmonella* ssp. | Italy          | EU        | FAOWHO, 2011 |
| cleaning       | *Salmonella* ssp. | USA            | non-EU    | Gandhi, 2008 |
| environment    | *Salmonella* ssp. | USA            | non-EU    | ASTA, 2011 |
|                | *Salmonella* ssp. | USA            | non-EU    | Gandhi, 2008 |
| heating        | *Salmonella* ssp. | USA            | non-EU    | ASTA, 2011 |
|                | *Salmonella* ssp. | New Zealand    | non-EU    | ASTA, 2006 |
| packaging      | *Salmonella* ssp. | USA            | non-EU    | ASTA, 2011 |
|                | n.r.           | USA            | non-EU    | GMA, 2009 |
|                | *Salmonella* ssp. | USA            | non-EU    | Ahene et al., 2011 |
|                | Coliforms      | USA            | non-EU    | ASTA, 2006 |
| processing     | *Salmonella* ssp. | USA            | non-EU    | Naturland, 2002 |
|                | n.r.           | USA            | non-EU    | Naturland, 2002 |
|                | *Salmonella* ssp. | USA            | non-EU    | Ahene et al., 2011 |
|                | Coliforms      | USA            | non-EU    | ASTA, 2006 |

Peanut butter 31

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| Food item | FoNAO category | Critical point | Pathogen | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------|---------|-----------|--------------|
| raw material | n.r. | USA | non-EU | ASTA, 2011 |
| Salmonella spp. | USA | non-EU | Gandhi, 2008 |
| Salmonella spp. | USA | non-EU | Gandhi, 2008 |
| Coliforms | USA | non-EU | Ahene et al., 2011 |
| Salmonella spp. | New Zealand | non-EU | ASTA, 2006 |
| roasting | Salmonella spp. | USA | non-EU | ASTA, 2011 |
| n.r. | USA | non-EU | NZFSA, 2010 |
| shelling | n.r. | USA | non-EU | Naturland, 2002 |
| storage | Salmonella spp. | USA | non-EU | ASTA, 2011 |
| Salmonella spp. | USA | non-EU | Gandhi, 2008 |
| Salmonella spp. | USA | non-EU | Ahene et al., 2011 |
| Coliforms | USA | non-EU | ASTA, 2006 |
| transport | Salmonella spp. | USA | non-EU | Gandhi, 2008 |
| Coliforms | USA | non-EU | ASTA, 2006 |
| water | Salmonella spp. | USA | non-EU | ASTA, 2011 |
| drying | n.r. | India | non-EU | ASTA, 2006 |
| heating | n.r. | India | non-EU | ASTA, 2006 |
| packaging | n.r. | India | non-EU | ASTA, 2008 |
| raw material | n.r. | India | non-EU | ASTA, 2008 |
| water | n.r. | India | non-EU | ASTA, 2008 |
| Soy Nuts 31 | n.r. | India | non-EU | Decagon, 2010 |
| Black pepper 32 | cleaning | n.r. | India | non-EU | DM, 2005 |
## Food of plant origin with low water content

| Food item | FoNAO category | Critical point | Pathogen* | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------|---------|-----------|--------------|
| n.r.      | India          | n.r.           |           | non-EU  | HEC, 2009 |              |
| drying    | n.r.           | India          | n.r.      | non-EU  | DHV, 2010 |              |
| n.r.      | India          | n.r.           |           | non-EU  | EC, 2004  |              |
| n.r.      | India          | n.r.           |           | non-EU  | HEC, 2009 |              |
| n.r.      | India          | n.r.           |           | non-EU  | HEC, 2009 |              |
| environment | n.r.           | India          | n.r.      | non-EU  |           | Hampikyan et al., 2009 |
| equipment | n.r.           | India          | n.r.      | non-EU  | EC, 2004  |              |
| fecal matter | n.r.           | USA            | n.r.      | non-EU  | ITC, 2010 |              |
| harvesting | n.r.           | Thailand       | n.r.      | non-EU  | ITC, 2010 |              |
| heating   | n.r.           | India          | n.r.      | non-EU  | DHV, 2010 |              |
| n.r.      | United Kingdom | n.r.           |           | EU      | ITC, 2010 |              |
| packaging | n.r.           | India          | n.r.      | non-EU  | EC, 2004  |              |
| n.r.      | India          | n.r.           |           | non-EU  | GMA, 2009 |              |
| personnel | n.r.           | India          | n.r.      | non-EU  | GMA, 2009 |              |
| n.r.      | Thailand       | n.r.           |           | non-EU  | Peter, 2004 |              |
| processing | n.r.           | India          | n.r.      | non-EU  | DHV, 2010 |              |
| n.r.      | India          | n.r.           |           | non-EU  | DHV, 2010 |              |
| storage   | n.r.           | India          | n.r.      | non-EU  | EC, 2004  |              |
| n.r.      | India          | n.r.           |           | non-EU  | HEC, 2009 |              |
| n.r.      | Thailand       | n.r.           |           | non-EU  | Peter, 2004 |              |
| threshing | n.r.           | Indonesia      | n.r.      | non-EU  | HEC, 2009 |              |
| transport | n.r.           | India          | n.r.      | non-EU  | EC, 2004  |              |

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| Food item | FoNAO category | Critical point | Pathogen* | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|-----------|---------|-----------|--------------|
| Herbs     | 32             | antimicrobial treatment | n.r.      | non-EU  | non-EU    | Stankovic et al., 2006 |
|           |                | cleaning         | n.r.      | non-EU  | non-EU    | Stankovic et al., 2006 |
|           |                | drying           | n.r.      | EU      | EU        | SBI, 2012     |
|           |                |                 | n.r.      | non-EU  | non-EU    | UNIDO, 2005   |
|           |                |                 | n.r.      | Poland  | EU        | UNIDO, 2005   |
|           |                | packaging        | n.r.      | non-EU  | non-EU    | UNIDO, 2005   |
|           |                | personnel        | n.r.      | EU      | EU        | SBI, 2012     |
|           |                | processing       | n.r.      | EU      | EU        | Shamsuddeen, 2009 |
|           |                |                 | n.r.      | Poland  | EU        | USDA, 1999    |
|           |                | storage          | n.r.      | EU      | EU        | SQA, 2010     |
|           |                | transport        | n.r.      | EU      | EU        | SBI, 2012     |
| Nuts      | 32             | cleaning         | n.r.      | USA     | non-EU    | Beuchat, s.a. |
| Pepper    | 32             | cleaning         | n.r.      | Indonesia | non-EU | Beuchat, s.a. |
|           |                | drying           | n.r.      | Indonesia | non-EU | CFIA, 2008 (b) |
|           |                |                 | n.r.      | Nigeria  | non-EU    | CFIA, 2008b   |
|           |                | environment      | n.r.      | Indonesia | non-EU | CFIA, 2008 (b) |
|           |                | fecal matter     | *Salmonella spp.* | USA     | non-EU    | Beuchat, s.a. |
|           |                | packaging        | n.r.      | Indonesia | non-EU | CFIA, 2008 (b) |
|           |                | personnel        | n.r.      | Indonesia | non-EU | CFIA, 2008 (b) |
| Food item | FoNAO category | Critical point | Pathogena | Country  | EU/non-EU | Reference(s) |
|-----------|---------------|---------------|------------|----------|-----------|--------------|
| segregation | n.r.           | Indonesia | non-EU    | CFIA, 2008a |
| storage | n.r.           | Indonesia | non-EU    | CFIA, 2008a |
| transport | n.r.           | Indonesia | non-EU    | CFIA, 2008a |
| water | n.r.           | Indonesia | non-EU    | CFIA, 2008a |
| Spices | 32 | antimicrobial treatment | n.r. | Ghana | non-EU | CFIA, 2008b |
| | | | n.r. | USA | non-EU | EC, 2003 |
| | | | n.r. | Australia | non-EU | Kumar et al., 2006 |
| | | | n.r. | non-EU | non-EU | FAOWHO, 2011 |
| | | cleaning | n.r. | Ghana | non-EU | CFIA, 2008b |
| | | | n.r. | USA | non-EU | FDA, 1999 |
| | | | n.r. | non-EU | non-EU | FAOWHO, 2011 |
| | | drying | n.r. | Australia | non-EU | Kumar et al., 2006 |
| | | | n.r. | EU | EU | Saroj et al., 2006 |
| | | | n.r. | Turkey | non-EU | T.H.P. van Duynhoven et al., 2002 |
| | | | n.r. | Pakistan | non-EU | Bari et al., 2011a |
| | | | n.r. | Ethiopia | non-EU | Bari, s.a. |
| | | | n.r. | non-EU | non-EU | FAOWHO, 2011 |
| | environment | n.r. | USA | non-EU | EC, 2003 |
| | | | n.r. | Turkey | non-EU | Bari et al., 2011a |
| | | | n.r. | Pakistan | non-EU | Bari et al., 2011a |
| | equipment | n.r. | USA | non-EU | EC, 2003 |
| Food item | FoNAO category | Critical point | Pathogen | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------|---------|-----------|--------------|
| n.r.      | USA            | n.r.           | USA      | non-EU  | Freshfel, 2011 |
| n.r.      | Dubai          | n.r.           | USA      | non-EU  | Omafra, s.a. |
| fecal matter | n.r.         | Pakistan       | USA      | non-EU  | Bari, s.a. |
| n.r.      | Australia      | n.r.           | Pakistan | non-EU  | Freshfel, 2011 |
| n.r.      | United Kingdom | n.r.           | Pakistan | EU      | Buck et al., 2003 |
| n.r.      | India          | n.r.           | Pakistan | non-EU  | EFSA, 2011, online |
| n.r.      | USA            | n.r.           | Pakistan | non-EU  | FD, 2006 |
| n.r.      | Turkey         | n.r.           | Pakistan | non-EU  | Bari et al., 2011a |
| n.r.      | India          | n.r.           | Pakistan | non-EU  | Fahey et al., 2006 |
| n.r.      | non-EU         | n.r.           | Pakistan | non-EU  | FAO/WHO, 2011 |
| n.r.      | USA            | n.r.           | Pakistan | non-EU  | FD, 2006 |
| n.r.      | EU             | n.r.           | Pakistan | EU      | Saroj et al., 2006 |
| n.r.      | Nigeria        | n.r.           | Pakistan | non-EU  | Fahey et al., 2006 |
| n.r.      | Ghana          | n.r.           | Pakistan | non-EU  | CFIA, 2008b |
| n.r.      | USA            | n.r.           | Pakistan | non-EU  | Freshfel, 2011 |
| n.r.      | EU             | n.r.           | Pakistan | EU      | Sharma et al., 2004 |
| n.r.      | USA            | n.r.           | Pakistan | non-EU  | Sharma et al., 2004 |
| n.r.      | India          | n.r.           | Pakistan | non-EU  | Fahey et al., 2006 |
| n.r.      | USA            | n.r.           | Pakistan | non-EU  | FD, 2006 |
| n.r.      | Ghana          | n.r.           | Pakistan | non-EU  | CFIA, 2008b |
| n.r.      | USA            | n.r.           | Pakistan | non-EU  | FDA, 1999 |
| n.r.      | EU             | n.r.           | Pakistan | EU      | Sharma et al., 2004 |
### Food of plant origin with low water content

| Food item               | FoNAO category | Critical point | Pathogen* | Country | EU/non-EU | Reference(s) |
|-------------------------|----------------|----------------|-----------|---------|-----------|--------------|
| Salmonella spp.         |                 |                |           | USA     | non-EU    | Sharma et al., 2004 |
| n.r.                    |                |                |           | United Kingdom | EU | EFSA, 2011, online |
| Clostridium perfringens |                |                |           | Serbia  | non-EU    | Fahey et al., 2006 |
| Escherichia coli        |                |                |           | Serbia  | non-EU    | Fahey et al., 2006 |
| transport               | n.r.           |                |           | USA     | non-EU    | FDA, 1999    |
|                         | n.r.           |                |           | EU      | EU        | Sharma et al., 2004 |
| water                   | n.r.           |                |           | USA     | non-EU    | Freshfel, 2011 |
|                         | n.r.           |                |           | Australia | non-EU | OCCHD, s.a. |
|                         | n.r.           |                |           | Pakistan | non-EU | Bari, s.a. |
|                         | n.r.           |                |           | United Kingdom | EU | Fahey et al., 2006 |
| Thyme                   | 32             | antimicrobial treatment | n.r.     | United Kingdom | EU | Food Standards Agency, s.a. |
| White pepper            | 32             | cleaning       | Salmonella spp. | USA | non-EU | FSAI, 2011 |
|                         |                | packaging      | Salmonella spp. | USA | non-EU | FSANZ, 2012 |
|                         |                | processing     | Salmonella spp. | USA | non-EU | FSAI, 2011 |
|                         |                | storage        | Salmonella spp. | USA | non-EU | FSANZ, 2012 |
| Chocolate products      | 33             | cleaning       | n.r.      | Switzerland | non-EU | FSANZ, 2012 |
|                         |                | drying         | Coliforms | Brazil   | non-EU | NSW Food Authority, s.a. |
|                         |                |                | Escherichia coli | Brazil | non-EU | NSW Food Authority, s.a. |
|                         |                |                | Salmonella spp. | USA | non-EU | Saroj et al., 2006 |
|                         |                |                | Listeria spp. | USA | non-EU | Saroj et al., 2006 |

*Thyme, White pepper, and Chocolate products are examples of food items that may require specific handling and processing to prevent contamination by various pathogens. The table includes details on the critical points where these pathogens are most likely to be found, along with the country of origin and the reference(s) used to support the findings.*

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## Food of plant origin with low water content

| Food item   | FoNAO category | Critical point | Pathogen | Country | EU/non-EU | Reference(s) |
|-------------|----------------|----------------|----------|---------|-----------|--------------|
|             |                | environment    | *Escherichia coli* | USA     | non-EU    | Schrader, 2002 |
|             |                |                | *Staphylococcus spp.* | USA     | non-EU    | Schrader, 2002 |
|             |                | harvesting     | *Salmonella spp.* | Belgium | EU        | Mohle-Boetani et al., 2009 |
|             |                |                | *Listeria spp.* | Belgium | EU        | MPI, 2001 |
|             |                |                | *Escherichia coli* | Belgium | EU        | MPI, 2001 |
|             |                | processing     | *Staphylococcus spp.* | Belgium | EU        | Mohle-Boetani et al., 2009 |
|             |                | raw material   | *Salmonella spp.* | Switzerland | non-EU | FSANZ, 2012 |
|             |                |                | n.r. | Belgium | EU        | Mohle-Boetani et al., 2009 |

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| Food item | FoNAO category | Critical point | Pathogen<sup>a</sup> | Country | EU/non-EU | Reference(s) |
|-----------|----------------|----------------|----------------------|---------|----------|---------------|
| Salmonella spp. |  |  | Belgium | EU | MPI, 2001 |  |
| Listeria spp. |  |  | Belgium | EU | MPI, 2001 |  |
| Escherichia coli |  |  | Belgium | EU | MPI, 2001 |  |
| Staphylococcus spp. |  |  | Belgium | EU | MPI, 2001 |  |
| Salmonella spp. |  |  | Slovakia | EU | NSW Food Authority, s.a. |  |
| Salmonella spp. |  | roasting | USA | non-EU | OCCHD, s.a. |  |
| Salmonella spp. |  |  | Switzerland | non-EU | FSN, 2000 |  |
| Salmonella spp. |  |  | EU | EU | HDHHS., s.a. |  |
| Salmonella spp. |  |  | Belgium | EU | MPI, 2001 |  |
| Listeria spp. |  |  | Belgium | EU | MPI, 2001 |  |
| Escherichia coli |  |  | Belgium | EU | MPI, 2001 |  |
| Staphylococcus spp. |  |  | Belgium | EU | NSW Food Authority, s.a. |  |
| Salmonella spp. |  | storage | USA | non-EU | NSW Food Authority, s.a. |  |
| Salmonella spp. |  |  | Switzerland | non-EU | HDHHS., s.a. |  |
| Coliforms |  |  | Brazil | non-EU | NSW Food Authority, s.a. |  |
| Escherichia coli |  |  | Brazil | non-EU | NSW Food Authority, s.a. |  |
| n.r. |  |  | USA | non-EU | Karagozlu et al., 2009 |  |
| n.r. |  | water | Switzerland | non-EU | HDHHS., s.a. |  |
| n.r. |  |  | Belgium | EU | MPI, 2001 |  |
| Food item      | FoNAO category | Critical point | Pathogen\(^a\) | Country | EU/non-EU | Reference(s) |
|---------------|----------------|----------------|----------------|---------|-----------|--------------|
| Beans         | 37             | drying         | n.r.           | United Kingdom | EU        | Karagozlu et al., 2009 |
|               |                | storage        | n.r.           | Colombia  | non-EU    | Karagozlu et al., 2009 |
|               |                |                | n.r.           | South Africa | non-EU    | Karagozlu et al., 2009 |
|               |                |                | n.r.           | USA      | non-EU    | Karagozlu et al., 2009 |
| Tarhana       | 37             | cooling        | n.r.           | Turkey    | non-EU    | Karagozlu et al., 2009 |
|               |                | drying         | n.r.           | Turkey    | non-EU    | Sengun et al., 2012   |
|               |                |                | n.r.           | Turkey    | non-EU    | Sengun et al., 2012 |
|               |                |                | n.r.           | Turkey    | non-EU    | Peter, 2004          |
|               |                | heating        | n.r.           | Turkey    | non-EU    | Karagozlu et al., 2009 |
|               |                |                | n.r.           | Turkey    | non-EU    | Ucar et al., 2011    |
|               |                | packaging      | n.r.           | Turkey    | non-EU    | Ahmed, s.a.          |
|               |                | processing     | n.r.           | Turkey    | non-EU    | Sengun et al., 2012  |
|               |                | raw material   | n.r.           | Turkey    | non-EU    | Ahmed, s.a.          |
|               |                | receiving      | n.r.           | Turkey    | non-EU    | Ahmed, s.a.          |
|               |                | sieving        | n.r.           | Turkey    | non-EU    | Ahmed, s.a.          |
|               |                | storage        | n.r.           | Turkey    | non-EU    | University of California, 2006 |

\(^a\)n.r.= not reported concerning a specific pathogen
### Table 24: Examples of Guidelines and Standards to improve food quality reported for the food items listed in Table 20 and 21.

| Food item | FoNAO category | Title | Organization | Country | Reference(s) |
|-----------|----------------|-------|--------------|---------|---------------|
| Seeds for sprouting | 28 | Code of hygienic practice for fresh fruits and vegetables | Food and Agriculture Organization of the United Nations/World Health Organization | Italy | FAO/WHO, 2011 |
| Sesame | 28 | Clean, Safe Spices. Guidance from the American Spice Trade Association | American Spice Trade Association | USA | ASTA, 2011 |
| Sprouts | 28 | Food Safety Practices Guidance for Sprout Manufacturers | Canadian Food Inspection Agency | Canada | CFIA, 2008b |
| | | HACCP Generic Model for Sprouts Grown in Water | Canadian Food Inspection Agency | Canada | CFIA, 2008a |
| | | Guidelines on Safe Production of Ready-to-Eat Sprouted Seeds (Sprouts) | Food Safety Authority of Ireland | Ireland | Food Safety Authority of Ireland, 2011 |
| | | Sprouted Seeds. Good Manufacturing Practices Guidebook | Ministry of Agriculture, Food and Rural Affairs | Canada | Omafra, s.a. |
| | | Comparison of different guidelines and practices for sprout production | The European Fresh Produce Association | EU | Freshfel, 2011 |
| Nuts | 31 | Industry Handbook for Safe Processing of Nuts | Grocery Manufacturers Association | USA | GMA, 2010 |
| | | Nut Handling and Processing for Confectioners and Small Nut Roasters | University of Georgia | USA | Hurst, s.a. |
| Black pepper | 32 | Draft of Good Agricultural Practices for Pepper | International Pepper Community | Indonesia | IPC, 2007 |
| | | Good Agricultural Practices for Peppers | National Bureau of Agricultural Commodity and Food Standards | Thailand | TAS, 2005 |
| Herbs | 32 | Handbook of herbs and spices | - | United Kingdom | Peter, 2004 |
| Pepper | 32 | Good Manufacturing Practices | International Pepper Community | Indonesia | IPC, 2012 |
| Spices | 32 | ASTA Safety Guidelines for Spices Sold in the United States | American Spice Trade Association | USA | ASTA, 2008 |
| | | HACCP Guide for Spices & Seasonings | American Spice Trade Association | USA | ASTA, 2006 |
| | | Microbial Safety in Spices - White Paper | American Spice Trade Association | USA | ASTA, s.a. |
| | | Guidelines for Environmental Health Officers on the Interpretation of Microbiological Analysis Data of Food | Department of Health - Directorate: Food, South Africa | South Africa | DOH, s.a. |
| | | HACCP Guidelines for Food Manufacturing Premises | Dubai Municipality | Dubai | DM, 2005 |
Food of plant origin with low water content

| Food item | FoNAO category | Title | Organization | Country | Reference(s) |
|-----------|----------------|-------|--------------|---------|---------------|
| Beans     | 37             | Dry Beans - Production Guideline | Department of Agriculture, Forestry and Fisheries | South Africa | DAFF, 2010 |

Table 25: Trade volumes of FoNAO with low water content (that have been reported in association with biological hazards) imported from third countries into the EU from 2002 to 2011.

| Food item | FoNAO category | Product description (EUROSTAT) | Import EU27 (Quantity in 100 kg) |
|-----------|----------------|--------------------------------|----------------------------------|
|          |                |                                 | 2011    | 2010    | 2009    | 2008    | 2007    | 2006    | 2005    | 2004    | 2003    | 2002    |
| Wheat    | 24             | durum wheat; common wheat and meslin seed | 17,953,490 | 22,127,409 | 21,130,969 | 13,177,396 | 19,092,580 | 20,070,111 | 17,735,894 | 17,961,592 | 17,776,908 | 11,824,745 |
| Spices   | 32             | mixtures of different types of spices (incl. crushed or ground) | 27,427   | 29,540   | 36,663   | 37,721   | 37,028   | 38,004   | 38,351   | 38,137   | 37,480   | 32,635   |
| Saffron  | 32             | Saffron (incl. crushed or ground) | 3,753    | 3,059    | 1,202    | 1,453    | 1,081    | 1,447    | 1,935    | 1,405    | 1,527    | 772      |
| Nuts     | 31             | nuts and other seeds, incl. mixtures, prepared or preserved (excl. prepared or preserved with vinegar, preserved with sugar but not laid in syrup, jams, fruit jellies, marmalades, fruit purée and pastes, obtained by cooking, groundnuts, roasted nuts, and coconuts, cashew nuts, brazil nuts, areca "betel" nuts, cola nuts and macadamia nuts and mixtures containing >= 50% by weight of tropical fruits and nuts) | 1,002,920 | 937,868  | 889,182  | 903,599  | 948,059  | 1,000,090 | 955,034  | 1,020,715 | 715,118  | 656,369  |

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| Food item       | FoNAO category | Product description (EUROSTAT) | Import EU27 (Quantity in 100 kg) |
|-----------------|----------------|--------------------------------|---------------------------------|
|                 |                |                                | 2011  | 2010  | 2009  | 2008  | 2007  | 2006  | 2005  | 2004  | 2003  | 2002  |
| Red pepper      | 32             | pepper of the genus piper (incl. Crushed or ground) | 618,350 | 649,332 | 609,661 | 609,791 | 659,220 | 663,908 | 603,739 | 625,568 | 657,928 | 632,463 |
| Black pepper    | 32             | pepper of the genus piper (incl. Crushed or ground) | 618,350 | 649,332 | 609,661 | 609,791 | 659,220 | 663,908 | 603,739 | 625,568 | 657,928 | 632,463 |
| Rice            | 25             | rice in husk for sowing; round grain rice in husk + medium grain rice in husk + long grain rice in husk (incl. for sowing and parboiled) | 528,461 | 21,486 | 25,973 | 292,413 | 69,635 | 165,093 | 130,505 | 320,850 | 448,577 | 1,010,101 |
| Rice            | 25             | round grain husked [brown] rice + medium grain husked [brown] rice + long grain husked [brown] rice (incl. parboiled) | 8,528,825 | 6,562,835 | 7,544,244 | 9,299,990 | 9,191,826 | 7,894,089 | 8,346,353 | 8,324,560 | 8,222,332 | 7,751,538 |
| Rice            | 25             | semi-milled round grain rice + semi-milled medium grain rice + semi-milled long grain rice (incl. parboiled) AND wholly milled round grain rice, whether or not polished or glazed + wholly milled medium grain rice, whether or not polished or glazed + wholly milled long grain rice, whether or not polished or glazed (incl. parboiled) | 4,670,532 | 4,071,287 | 3,983,873 | 4,345,346 | 3,169,548 | 2,986,192 | 2,123,544 | 2,990,925 | 3,329,734 | 3,102,509 |
| Rice            | 25             | broken rice                   | 1,179,119 | 2,431,065 | 3,216,132 | 2,466,624 | 2,122,440 | 2,156,626 | 1,329,103 | 1,407,834 | 1,846,145 | 1,800,792 |
| Pistachios      | 31             | roasted almonds and pistachios | 30,004 | 43,360 | 29,537 | 23,106 | 19,562 | 17,180 | 21,833 | 24,804 | 31,262 | 33,930 |
| Raw almond      | 31             | roasted almonds and pistachios | 30,004 | 43,360 | 29,537 | 23,106 | 19,562 | 17,180 | 21,833 | 24,804 | 31,262 | 33,930 |
| Cumin           | 32             | cumin seeds                   | 106,891 | 107,915 | 101,019 | 97,807 | 98,070 | 87,266 | 82,113 | 76,394 | 78,980 | 80,991 |
| Tarhana         | 37             | flour of common wheat and spelt | 319,546 | 122,091 | 95,720 | 57,409 | 37,456 | 35,702 | 40,640 | 532,965 | 78,946 | 93,560 |

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| Food item       | FoNAO category | Product description (EUROSTAT)                                                                 | Import EU27 (Quantity in 100 kg) |
|-----------------|----------------|-----------------------------------------------------------------------------------------------|----------------------------------|
| Beans           | 37             | Shelled and unshelled beans "Vigna spp., Phaseolus spp.", prepared or preserved otherwise than by vinegar or acetic acid (excl. frozen) | 474,572 381,606 368,422 523,881 480,688 447,963 411,850 419,824 379,407 401,471 |
| Maize flour porridge | 27        | maize flour                                                                                   | 129,459 113,192 128,702 140,317 97,029 93,935 77,205 71,171 82,407 118,084 |
| Alfalfa seeds   | 28             | alfalfa seed for sowing                                                                        | 21,205 20,717 14,349 49,251 70,428 60,477 56,414 58,802 33,425 30,566 |
| Linseed         | 28             | linseed (incl. for sowing)                                                                     | 4,462,261 5,236,375 4,121,814 4,500,378 6,988,237 5,021,312 4,783,558 5,296,201 5,830,034 6,042,934 |
| Linseed         | 28             | linseed (incl. for sowing)                                                                     | 1,034,218 1,065,035 1,094,638 1,084,394 1,013,373 997,533 1,012,069 1,034,064 932,885 |
| Sesame          | 28             | sesame seeds, whether or not broken (incl. for sowing)                                         | 4,064,088 2,435,151 6,219,152 3,383,534 5,109,208 5,732,678 5,270,927 7,659,821 9,218,171 7,787,282 |
| Sunflower       | 28             | sunflower seeds, whether or not broken (incl. for sowing, shelled or in grey and white striped shell) | 115,873 120,380 108,189 105,167 108,277 97,924 98,572 92,276 111,797 109,281 |

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### Table 26: Major outcomes of European consumption studies relating to FoNAO regarding consumption rates, consumer groups, and regional effects.

| Food Item(s)        | Age-Class       | Method                        | No. of surveyed participants | Scope of the study                      | Outcome 1 (consumption rate)                                                                                                                                                                                                 | Outcome 2* (observed differences between groups)                                                                                     | Outcome 3* (observed differences between counties/environments) | Research project | Country/countries | Reference(s) |
|---------------------|-----------------|-------------------------------|------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------|------------------|----------------|
| **Apple**           | Adults (50-70 yrs) | Fruit-frequency question.     | 4271                         | Apple and peach consumption frequency  | Highest consumption Poland (55% > 5 times/wk) and Italy (39.3% 3-5 times/wk); lowest consumption Netherlands and Spain                                                                                                   | Differences between gender (females higher consumption) and age groups                                                                                                           | Differences between countries                                                                                                         | ISAFRUIT         | Germany, Poland, Switzerland, France, Netherland, Italy, Spain | Konopacka et al. 2010 |
| **Peach**           | Adults (50-70 yrs) | Fruit-frequency question.     | 499                          | Apple and peach consumption frequency  | Highest consumption France (48% > 3-5 times/wk, 40% > 5 times/wk); lowest consumption Germany                                                                                                                       | Differences between gender (females higher consumption) and age groups                                                                                                           | Differences between countries                                                                                                         | ISAFRUIT         | Germany, Poland, Spain, France, Italy | Konopacka et al. 2010 |
| **Fruit and soft drinks** | Adolescents (11, 13, 15 yrs) | standardized question. | 114 558                      | Health behaviour in school aged children | 33% consume fruit daily; 26% consume soft drinks daily                                                                                                                              | Girls and younger pupils consume fruit more often and soft drinks less often                                                                                                     | Differences between schools, countries, regions, and family material wealth                                                          | HBSSC            | 28 European countries or regions | Vereecken et al. 2005a |
| **Fruit, vegetables and soft drinks** | Adolescents (11, 13, 15 yrs) | stand. question. | 162 305                      | Health behaviour in school aged children | Fruit consumption 2.8-5/ wk; vegetables 2.4-5.5/ wk, soft drinks 2.5-5/ wk                                                                                                         | n.r.                                                                                                                                         | Differences between countries                                                                                                         | HBSSC            | 35 Countries (Europe, Israel, N-America) | Vereecken et al. 2005b |
| Food Item(s)          | Age-Class          | Method                      | No. of surveyed participants | Scope of the study                                      | Outcome 1 (consumption rate) | Outcome 2* (observed differences between groups) | Outcome 3* (observed differences between counties/environments) | Research project | Country/countries                        | Reference(s) |
|----------------------|--------------------|-----------------------------|------------------------------|--------------------------------------------------------|----------------------------|-----------------------------------------------|---------------------------------------------------------------|----------------|-------------------------------------------|---------------|
| Fruit and vegetables | -                  | stand. question.            | 13 305                       | Factors related to fruit and vegetable intake          | 43.5 % consume fruit daily; 46.1 % consume vegetables daily | Gender differences          | Differences between countries                  | ProChildren Project | Austria, Belgium, Denmark, Iceland, Netherland, Nor-way, Portugal, Spain, Sweden | Brug et al. 2008 |
| Fruit and vegetables | Adolescents (10-13 years) | 24 hours recall            | 1489                         | Effect of fruit and vegetable promotion                | Total fruit and vegetable intake 221-256 g/d                  | n.r.                           | n.r.                                          | ProChildren Project | Norway, Netherland, Spain                 | Velde et al. 2008 |
| Fruit and vegetables | Adolescents (11 yrs) | Food frequency question.; 24 hrs recall | 1919 | Influence of school environment on fruit and vegetable intake | 40 % consume > 200 g fruit/d; 25% consume > 130 g vegetables/d; 64 % consume fruit almost daily; 46.9 % consume vegetables almost daily | n.r.                           | n.r.                                          | ProChildren Project | Denmark                                   | Krolner et al. 2009 |
| Fruit and vegetables | Adolescents (11-13 yrs) | Food Frequency Questionnaire; 24 hrs recall | 1601 | Influence of parenting styles on fruit and vegetable consumption | 155 g/d fruits and 88 g/d vegetable consumption            | n.r.                           | n.r.                                          | ProChildren Project | Portugal                                 | Franchini et al. 2011 |
| Fruit and vegetables | Adolescents (9-11 yrs) | 24 hours recall            | 1612                         | Impact of school fruit tuck shops and school food policies on fruit and vegetable consumption | 0.69-0.74 portions/d | n.r.                           | n.r.                                          | -               | U.K.                                      | Moore and Tapper 2008 |

* n.r. = not reported
D. APPENDIX SPECIFIC TO THEMATIC AREA D

**Table 27:** FoNAO (low water content) item/pathogen combinations with highest numbers of outbreak cases, EU countries. Collective cases from multiple outbreaks are indicated in bold.

| Rank | Food item | FoNAO category | Pathogen | Country                      | Year            | Cases | Hospitalisations | Deaths | Reference(s)                                                                 |
|------|-----------|----------------|----------|------------------------------|-----------------|-------|------------------|--------|-----------------------------------------------------------------------------|
| 1    | Sprouts (fenugreek seeds) | 28 | E. coli O104:H4 (STEC O104:H4) | Germany; other EU countries (travel-related) | 2011 | 4033 | n.s. | 50 | CDC, 2011, online (e); Buchholz et al. 2011; EFSA, 2011; Frank et al. 2011; King et al. 2012; Kemper 2012 |
| 2    | Sprouts (bean sprouts, alfalfa sprouts) | 28 | Salmonella spp. | Denmark, Norway, U.K. | 2009-2011 | 386 | 38 | 1 | ECDC, 2009; ECDC, 2010; Emberland et al. 2007; Rimhanen-Finne et al. 2011, Werner et al. 2007 |
| 3    | Baby corn | 24 | Shigella sonnei | Denmark | 2007 | 120 | 13 | n.s. | Lewis et al., 2007 |
| 4    | White pepper | 32 | Bacillus cereus | Denmark | 2010 | 112 | 0 | 0 | ECDC, 2010 |
| 5    | Buckwheat | 24 | Bacillus cereus | Poland | 2009 | 52 | 0 | 0 | ECDC, 2009 |
| 6    | Aniseed | 32 | Salmonella Agona | Germany | 2002-2003 | 42 | 0 | 0 | Koch et al., 2005 |
| 7    | Almonds | 31 | Salmonella enteritidis | Sweden | 2005-2006 | 15 | n.s. | n.s. | Ledet Müller et al., 2007 |
| 8    | Rice | 25 | Bacillus cereus | Germany, Netherlands | 2007-2010 | 14 | 0 | 0 | ECDC, 2009; ECDC, 2010; |
| 9    | Curry | 32 | Bacillus cereus | Belgium | 2009 | 7 | 0 | 0 | ECDC, 2009 |
| 10   | Hemp flour | 27 | Salmonella Montevideo | Germany | 2010 | 4 | 1 | 0 | ECDC, 2010; Stöcker et al., 2011 |

*a Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking.

*b n.s. = not specified

Supporting publications 2013:EN-403

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Table 28: FoNAO (low water content) item/pathogen combinations causing outbreaks\(^a\) with highest numbers of hospitalisation, EU countries. Collective cases from multiple outbreaks are indicated in **bold**.

| Rank | Food item | FoNAO category | Pathogen | Country          | Year   | Cases | Hospitalisations | Deaths\(^b\) | Reference(s) |
|------|------------|----------------|----------|------------------|--------|-------|------------------|-------------|--------------|
| **1** | Sprouts (bean sprouts, alfalfa sprouts) | 28 | *Salmonella* spp. | Denmark, Finland, Norway, Sweden, U.K. | 2009-2011 | 386 | 38 | 1 | ECDC, 2009; ECDC, 2010; Emberland et al. 2007; Rimhanen-Finne et al. 2011, Werner et al. 2007 |
| 2 | Baby corn | 24 | *Shigella sonnei* | Denmark | 2007 | 120 | 13 | n.s. | Lewis et al., 2007 |
| 3 | Hemp flour | 27 | *Salmonella Montevideo* | Germany | 2010 | 4 | 1 | 0 | ECDC, 2010; Stöcker et al., 2011 |

\(^a\) Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking.

\(^b\) n.s. = not specified

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Table 29: FoNAO (low water content) item/pathogen combinations causing outbreaks\(^a\) where cases of death have been reported, EU countries.

| Rank | Food item | FoNAO category | Pathogen | Country | Year | Cases | Hospital.\(^b\) | Deaths\(^b\) | Reference(s) |
|------|------------|----------------|----------|---------|------|-------|----------------|-------------|--------------|
| **1** | Sprouts (fenugreek seeds) | 28 | *E. coli* O104:H4 (STEC O104:H4) | Germany, France, EU-travel related | 2011 | 4033 | n.s. | 50 | CDC, 2011, Buchholz et al. 2011, Frank et al. 2011, King et al. 2012, Kemper 2012 |
| 2 | Sprouts (bean sprouts, alfalfa sprouts) | 28 | *Salmonella* spp. | Denmark, Norway, Sweden, U.K. | 2009-2011 | 386 | 38 | 1 | ECDC, 2009; ECDC, 2010; Emberland et al. 2007; Rimhanen-Finne et al. 2011, Werner et al. 2007 |

\(^a\) Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking.

\(^b\) n.s. = not specified

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Table 30: FoNAO (low water content) item/ pathogen combinations with highest numbers of outbreak cases, non EU countries. Collective cases from multiple outbreaks are indicated in bold.

| Rank | Food item | FoNAO category | Pathogen | Country | Year | Cases | Hospitalisations | Deaths | Reference(s) |
|------|------------|----------------|----------|---------|------|-------|-----------------|--------|---------------|
| 1    | Sprouts (alfalfa, bean sprouts) | 28 | Salmonella spp. | Several multi-state outbreaks USA (26, 14, 11, and 5 states), Canada | 2005-2011 | 1036 | 50 | 0 | CDC, 2009; CDC, 2010; CDC, 2011; MMWR 2009, 58 (18), 500-503; Rohokar et al., 2008 |
| 2    | Black and red pepper | 32 | Salmonella Montevideo | Multi-state outbreak USA (44 states) | 2010 | 272 | 52 | 0 | CDC, 2010 |
| 3    | Bamboo shoots | 37 | Clostridium botulinum | Thailand | 2006 | 209 | 25 | 0 | Kongsaengdao et al., 2006 |
| 4    | Corn (baby corn) | 24 | Shigella sonnei | Australia | 2007 | 58 | n.s. | n.s. | Strafford et al., 2007 |
| 5    | Turkish Pine Nuts | 31 | Salmonella Enteritidis | Multi-state outbreak USA (5 states) | 2011 | 43 | 2 | 0 | CDC, 2011 |
| 6    | Clover sprouts | 28 | Escherichia coli O26 | Multi-state outbreak USA (11 states) | 2012 | 29 | 7 | 0 | |
| 7    | Almonds | 31 | Salmonella Enteritidis | USA, Canada | 2003-2004 | 29 | 0 | 0 | MMWR, 2004 (c) |
| 8    | Sprouts (alfalfa and clover sprouts, fenugreek seeds) | 28 | Pathogenic E. coli (E. coli O157, E. coli O104: H4) | USA, Canada, Switzerland | 2003, 2011, 2012 | 49 | 9 | 1 | Buchholz et al. 2011, CDC, 2011, Ferguson et al., 2005; Frank et al. 2011, King et al. 2012, Kemper 2012; CDC, 2012, online (c) |
| 9    | Hazelnut | 31 | E. coli O157:H7 | Multi-state outbreak USA (3 states) | 2011 | 8 | 4 | 0 | CDC, 2011, online (h), Miller et al., 2012 |

* Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking.

b n.s. = not specified
Table 31: FoNAO (low water content) item/pathogen combinations causing outbreaks\(^a\) with highest numbers of hospitalisation and cases of death, non EU countries. Collective cases from multiple outbreaks are indicated in **bold**.

| **Rank** | **Food item** | **FoNAO** | **Pathogen** | **Country** | **Year** | **Cases** | **Hospital.\(^b\)** | **Deaths\(^b\)** | **Reference(s)** |
|----------|---------------|-----------|--------------|-------------|----------|-----------|-------------------|----------------|-----------------|
| **Hospitalisations** | | | | | | | | | |
| 2 | Black and red pepper | 32 | *Salmonella* Montevideo | Multi-state outbreak USA (44 states) | 2010 | 272 | 52 | 0 | CDC, 2010 |
| 1 | Sprouts (alfalfa, bean sprouts) | 28 | *Salmonella* spp. | Several multi-state outbreaks USA (26, 14, 11, and 5 states), Canada | 2005–2011 | 1036 | 50 | 0 | CDC, 2009; CDC, 2010; CDC, 2011; MMWR 2009, 58 (18), 500-503; Rohekar et al., 2008 |
| 3 | Bamboo shoots | 37 | *Clostridium botulinum* | Thailand | 2006 | 209 | 25 | 0 | Kongsangdao et al., 2006 |
| 4 | Clover sprouts | 28 | *Escherichia coli* O26 | Multi-state outbreak USA (11 states) | 2012 | 29 | 7 | 0 | CDC, 2012, online (c) |
| 5 | Sprouts (alfalfa and clover sprouts, fenugreek seeds) | 28 | Pathogenic *E. coli* (E. coli O157, E. coli O104:H4) | USA, Canada, Switzerland | 2003, 2011, 2012 | 49 | 9 | 1 | Buchholz et al. 2011, CDC, 2011, Ferguson et al., 2005; Frank et al. 2011, King et al. 2012, Kemper 2012; CDC, 2012, online (c) |
| 6 | Hazelnut | 31 | *E. coli* O157:H7, multi-state outbreak USA (3 states) | 2011 | 8 | 4 | 0 | CDC, 2011, online (h), Miller et al., 2012 |
| 7 | Turkish Pine Nuts | 31 | *Salmonella Enteritidis* | Multi-state outbreak USA (5 states) | 2011 | 43 | 2 | 0 | CDC, 2011 |
| 8 | Almonds | 31 | *Salmonella Enteritidis* | USA, Canada | 2003–2004 | 29 | 0 | 0 | MMWR, 2004 (c) |
| **Cases of death** | | | | | | | | | |
| 1 | Sprouts (alfalfa and clover sprouts, fenugreek seeds) | 28 | Pathogenic *E. coli* (E. coli O157, E. coli O104:H4) | USA, Canada, Switzerland | 2003, 2011, 2012 | 49 | 9 | 1 | Buchholz et al. 2011, CDC, 2011, Ferguson et al., 2005; Frank et al. 2011, King et al. 2012, Kemper 2012; CDC, 2012, online (c) |

\(^a\) Outbreaks traced back to the consumption of highly processed food items (containing FoNAO mixed with other ingredients of animal origin, e.g. meat, milk or egg products) were not included in the ranking. \(^b\) n.s. = not specified