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A systematic comparison of food intake data of the United States and the Netherlands for food allergen risk assessment

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ABSTRACT

National population-based food consumption surveys are used in food allergen risk assessment. It would be beneficial if food intake data is interchangeable between countries to bridge potential gaps present in national survey data, which is only possible when risk assessment outcomes for comparable food product groups between countries are fairly similar. Additionally, merged food intake data would enable risk assessments that cover scenarios for various countries, if based on the most critical situation.

Therefore, we systematically compared risk assessment outcomes for a broad range of food groups based on United States and Dutch population food consumption survey data. We calculated risks for 14 allergenic foods for 9 concentrations (1-10,000 ppm) to assess comparability.

Depending on the assumed allergen concentration, risk assessment outcomes for 20% (10 out of 49) food groups differed considerably. We consider the number of potentially relevant risk differences too high to conclude that food intake data from the US and The Netherlands can be used interchangeably. To allow risk assessments that cover scenarios for several countries, we recommend development and use of a food intake dataset based on the highest intake levels for each food group of the involved countries to facilitate risk management efforts and harmonization.

1. Introduction

There is growing evidence to suggest that food allergies are common and have increased in prevalence in the last decades (Sicherer and Sampson, 2018). Currently, no cure exists for the disorder; the only approach for the food allergic consumer is to avoid the consumption of the culprit allergenic food. This is often difficult due the unintended presence of allergenic material in products, resulting in the risk of an allergic reaction (Blom et al., 2018). Probabilistic food allergen risk assessment quantitively predicts the population risk for an adverse reaction due to unintended consumption of the culprit allergenic food and thereby supports allergen risk management.

In population-based food allergen risk assessment, exposure to the allergenic material is compared to the population's sensitivity to the allergenic substance. Exposure is determined by the intake of food products that contain allergenic proteins and the level of proteins in these products. Many countries investigate food intake of their population by conducting national food consumption surveys of which the results are stored in food consumption databases. The setup and differentiation in most food consumption databases is valuable from a nutritional point of view, but leads to interpretation challenges for allergen risk assessment. For allergen risk assessment, it is crucial to know the amount of food intake per eating occasion as an allergic reaction will occur likely within minutes to 2 h after food intake (Crevel et al., 2014). Additionally, the frequency of intake and the proportion of the population that consumes the food product is important (Kruizinga et al., 2008; Spanjersberg et al., 2007).

For risk assessment purposes it is highly preferable that food intake data is available for all population age groups, a large number of individuals and a broad range of food products. Data gaps can arise when national surveys are performed in a relative small study population, a specific target group such as pregnant women, or when a food product is consumed less frequently. To overcome these gaps for the application of allergen risk assessment, food intake data gathered from surveys from other countries may be used. Yet, this can only be achieved if risk

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Abbreviations

24-HDR	24-h dietary recall
DNFCS 2007-2010	Dutch National Food Consumption Survey 2007-2010
ED	Eliciting dose
NHANES	National Health and Nutrition Examination Survey
US	United States of America

assessment outcomes for comparable food groups between the countries are fairly similar. Furthermore, merging food intake data of various countries would greatly facilitate risk assessment and risk management efforts and harmonization among countries. However, if large differences exist in the risk assessment outcomes between countries due to differences in food intake, the data should not be merged. Instead, risk assessment could be based on the most critical situation, i.e. the highest intake amount of the countries involved, if an assessment would need to cover these various countries. To investigate comparability of food intake and the impact of possible differences in allergen risk assessment outcomes caused by differences in food intake amounts between countries, we conducted a case study using data from two well conducted food consumption surveys, i.e. those from the United States (US) and the Netherlands.

In the US, a population food consumption survey was performed by the National Health and Nutrition Examination Survey (NHANES). The program started in the 1960s and is designed to assess the health and nutritional status of adults and children in the US. Since 1999, the survey has been a continuous program with 2-year dataset cycles which has resulted in a comprehensive, publicly available overview of the food consumption of the American population. In the Netherlands, food consumption and nutritional status data have been collected periodically since 1987. As of 2003, the dietary data is collected for a period of four years with a break of every two years. Both countries utilize a two time non-consecutive 24-h dietary recall (24-HDR) method to register food intake. During the European Food Consumption Survey Method project, it was indicated that the two non-consecutive 24-HDR method is the most suitable method to get internationally comparable data on population means and distributions of actual intake (de Keyzer et al., 2015). Data for a broad range of food groups for the adult population from these surveys of these two countries were used for the comparison of allergen risk assessment outcomes.

2. Methods

2.1. Food consumption data

US consumption data for years 2003-2010 was obtained from the US National Health and Nutrition Examination Survey (NHANES) website (https://www.cdc.gov/nchs/nhanes/). Food consumption data was obtained for the US population aged 0 to >85 years. Food consumption data was obtained by two non-consecutive 24-HDRs in combination with a food frequency questionnaire (FFQ). Data from 15,227 adults aged 19-69 years of which both recall days were available were used for further analysis.

Dutch consumption data for years 2007-2010 was obtained from the Dutch National Food Consumption Survey (DNFCS) of the National Institute of Public Health and the Environment (https://www.rivm.nl/en). Food consumption data was obtained from adults aged 19-69 years. A total of 3819 individuals were included in the DNFCS 2007-2010. The food consumption survey was based on two non-consecutive 24-HDRs per individual in combination with questionnaires (van Rossum et al., 2011). Data of subjects for which both recall days were available were used for further analysis.

2.1.1. Grouping of food items

A total of 212,494 food records were available for the US, providing intake data on 7357 food items. For the Netherlands, 39,192 food records were available covering 786 food items. Food items of both countries were categorized into food groups based on similarity of food products as proposed by Birot et al. (2017) as part of the EU iFAAM (Integrated Approach to Food Allergen and Allergy Management) project. Some adjustments were made to the food groups of Birot et al. (2017) and additional groups were created for the reasons depicted below.

- The group 'Fruits and vegetables' was split in processed (both industrial and at home) fruits and vegetables and raw fruit and vegetables. The reason for this group split is that food allergic patients are often advised to consume processed fruit and vegetables to reduce the chance of an allergic reaction.
- The group of 'Meal replacements and meat imitates' was split into two separate groups, because meal replacements included products such as 'Instant breakfast' and 'Meal replacement bar', while meat imitates are vegetarian burgers, hot dogs, fillets, etcetera. These products were considered too diverse to fit into one group and were therefore categorized into the food groups 'Meal replacements' or 'Meat imitates'.
- Three food groups containing fish (products) and two food groups containing meat (products) were proposed by Birot et al. (2017) based on products similarity and risk. However, the type of food items within the various fish products food groups were fairly similar, which complicates linking food items to one of the food groups. The same was the case for the various meat products food groups. Therefore, in the present study, the various fish products food groups and meat products food groups were placed in one combined fish products group and one combined meat products food group, respectively.
- The food group 'Sweet confectionary (jam, marmalade)' was extended with food items of sweet sandwich toppings such as chocolate spread, honey, sprinkles and renamed to 'Sweet sandwich filling'.
- Food groups 'Small sweets - Sweet confectionaries unspecified' and 'Small sweets - sweet confectionaries specified' were merged to one food group 'Small sweets - Sweet confectionaries specified'
- A food group was added called 'Savory salads', which contains products that can be used as spreads or sandwich toppings, like egg salad and humus.

2.1.2. Food intake distribution

When a food item within a food group was eaten multiple times during the non-consecutive sampling days by a single person, the highest of the multiple intake amounts was selected for the analysis. This was done because this eating occasion represents the highest risk for an allergic reaction, in which the eating occasion was based on respondents defining the consumption as a meal or snack moment (e.g. breakfast, snack break). Food intake log-normal distributions were drawn for all food groups. The median and percentile intervals (2.5th and 97.5th) of food intake were calculated for each food group. The demographics analysis was only performed if $\geq$ 8 subjects were available. The risk analysis was not performed if the corresponding food group had fewer than 8 levels of consumption.

2.2. Risk assessment

A probabilistic risk assessment approach was applied to calculate the risk of consumption of food items from the various food groups for different levels of protein from allergenic foods in these food items (Fig. 1). This approach provides an estimation of the number of expected allergic responders in the allergic population using food items from the food groups, based on a quantitative probabilistic method (Spanjersberg

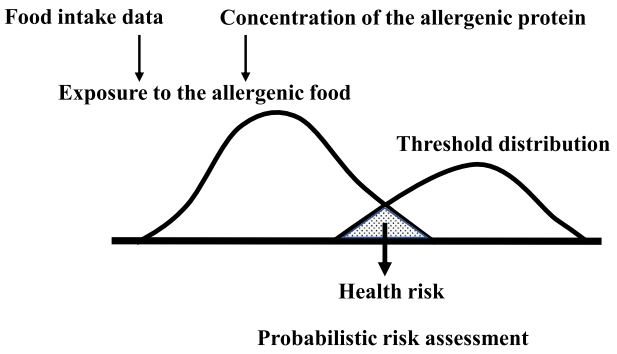


Fig. 1. (modified from Spanjersberg et al., 2007). Schematic presentation of probabilistic risk assessment, which provides an estimate of the health risk, i.e. the chance of an allergic reaction per number of allergic user eating occasions. The input parameters for this assessment are 1) the intake distribution of the total protein from the allergenic food, which is determined by the amount a food item from a food group consumed (in this study derived from national food consumption surveys, the NHANES and DNFCS) and the concentration of protein from the allergenic food in the consumed food and 2) the population threshold distribution for the protein from the allergenic food, derived from clinical data. See the method section 2.2 for the concentrations and the allergenic foods applied in the risk assessments.

et al., 2007). The risk of an allergic reaction per number of allergic user eating occasions of foods containing predefined levels of allergenic material was calculated using the US and the Netherlands intake data distributions. Threshold distributions for objective symptoms were obtained from the TNO FARRP allergen threshold database (ATDB) 3.0 as described by Houben et al. (2020) for mustard, egg, milk, celery, walnut, cashew, peanut, wheat, sesame, lupin, hazelnut, fish, soy and shrimp. The risk assessments were performed for predefined assumed concentrations of total protein from the 14 allergenic foods in food items (1, 3, 10, 30, 100, 300, 1000, 3000, 10.000 mg/kg). Although concentrations of 3000-10.000 mg/kg are not frequently present in food products, they were included to cover high levels of occasionally detected concentrations in food products.

The Monte Carlo method was applied for calculation of the risks. The analyses included 10,000 draws from the intake distribution of each food group and from the threshold distribution. Due to the random sampling in the Monte Carlo method, there is a slightly different risk estimate with a specific confidence interval when running more than one simulation. To account for this variation, a total of 100 simulations were performed from which the median risk and the 2.5% and 97.5% risk percentiles were calculated. The 2.5% and 97.5% percentile interval showed a comparable width to the confidence intervals of each individual simulation, indicating that the percentile interval appropriately represents the uncertainty in the risk calculation.

2.3. Comparison of risk assessment outcomes

Simulated risk outcomes were compared between the US and the Netherlands. By standardizing the threshold dose distribution and allergen concentrations for both countries, the difference in the risk assessment outcome was solely caused by the different food intake distributions. In this way, any difference in risk reflects a difference in food intake.

A difference in risk between the US and the Netherlands was considered statistically significant (p-value < 0.05) when the 2.5%-97.5% percentile intervals of the risk assessment outcomes based on food intake data for the two populations did not overlap. However, significant risk differences per this definition need not to automatically be considered relevant from a risk management perspective, as differences could be significant for outcomes such as 0.2% vs. 0.3%. As such, two methods were applied to evaluate the statistically significant differences in risk assessment outcomes between the US and the Netherlands for potential relevance.

Firstly, we calculated the ratio of the median risks of the risk assessment outcomes for the US and Dutch datasets. Although relatively arbitrary, we assumed that median risks that differ less than a factor 1.5 would generally not lead to fundamentally different risk management decisions (method 1). For example, we assumed that risks of e.g. 8% vs. 11% or 3% vs. 4% would result in comparable risk management decisions. We realize that risks differing more than a factor of 1.5 (e.g. 15% vs. 24%) might also not necessarily be considered relevant, but we set this arbitrary border quite conservative from a precautionary point of view. The cutoff of 1.5 was previously used for similar analyses (Blom et al., 2020).

Secondly, we drew up risk categories where we assumed that risks in a different category possibly make a difference from a risk management point of view (method 2). The Allergen Bureau of Australia-New Zealand has developed the Voluntary Incidental Trace Allergen Labeling system based on a cutoff of risk of 1% to determine the need for applying PAL (Allergen Bureau, 2019). The Scientific Committee of the Belgian Federal Agency for the Safety of the Food Chain (Wetenschappelijk Comité van het Federaal Agentschap voor de Veiligheid van de voedselketen) proposed reference doses based on ED05 values and thus used a cutoff of risk of 5% (FASFC, 2017). We therefore also used 1% and 5% as cutoff values for establishing risk categories. In order to give as much insight as possible over the whole range of potential risk outcomes, we additionally used 10%, 25%, and 50% as cutoff values. For the analyses, we assumed that risk outcomes based on data of the two countries in different risk categories would potentially lead to different risk management decisions and can therefore not be considered irrelevant.

For analysis and visualization purposes, all risk comparisons were pictured in heatmaps per concentration of the protein of the allergenic food. The food groups are presented on the y-axis, of which the order is based on the magnitude of the risk difference. The type of allergen is presented on the x-axis; the order is determined according to descending population sensitivity based on the total threshold distribution curve. The results per method are evaluated separately and discussed integrated.

2.4. Software

SAS 9.3, Copyright © 2002-2010 by SAS Institute Inc., Cary, NC, USA was used for statistical analysis of the demographics of the US and Netherlands consumption data.

R version 3.5.2, Copyright © 2017 The R Foundation for Statistical Computing was used for the probabilistic risk assessment, making use of R packages DescTools (version 0.99.35), EnvStats (version 2.3.1), fitdistrplus (version 1.0-14), gplots (version 3.0.3), Hmisc (version 4.4-0), msm (version 1.6.8), MASS (version 7.3-51.4), plyr (version 1.8.6), Rmisc (version 1.5) and scales (version 0.4.1).

3. Results

3.1. Food groups

Food items from the DNFCS and NHANES were categorized into 54 food groups. A total of 786 food items were assigned to 54 food groups for DNFCS and a total of 7357 food items were assigned to 55 food groups for NHANES. Only food items of the food group Baby food in NHANES could not be linked to a DNFCS food group due to lack of consumption of baby food items in the DNFCS. The food groups 'Spices and salt', 'Egg-based dishes', and 'Composite dishes' were excluded from the analysis, because none of the Dutch food items resembled US food items in these groups. The food groups 'Mashed potato powder' and 'Binding agent' had <8 consumers in NHANES and were therefore excluded from the analysis. In total 49 food groups were available for risk comparison.

3.2. Risk assessment

Risk assessment outcomes using US and Dutch food intake data were calculated for 49 food groups, 14 allergenic foods, and 9 allergenic protein concentration, allowing for in total 6174 comparisons of risk assessment outcomes for US and Dutch situations.

3.3. Assessment of risk difference: significance and relevance

Below we illustrate the ways of analyzing whether a risk difference is considered to be relevant with the example of the food group 'Pancakes and waffles'. Table 1 presents the intake amounts and the risk assessment outcomes for the food group 'Pancakes and waffles' and the allergenic foods wheat and mustard at concentrations of 1, 300 and 10,000 ppm. As shown, the 2.5th and 97.5th percentiles of the consumption distributions of 'Pancakes and waffles' for the US and the Netherlands are respectively 20.0-286.5 g and 10.0-430.0 g per eating occasion. For these consumption amounts and a concentration of 1 ppm wheat protein, the risk outcomes show low risks with overlapping confidence intervals for both countries, i.e. 0.0-0.1% risk for both the US and the Netherlands. Similar results were found for 1 ppm mustard. For the concentration of 300 ppm mustard, the risk difference is significant as confidence intervals for the US and The Netherlands do not overlap. In the current example, the median risks differ with a factor 1.21 (48.9% vs. 40.3%), and are therefore considered not relevant according to the factor 1.5-method (method 1). Also, both median risks for the two countries are in the risk category of 25-50% and neither considered relevant according to the risk category method (method 2). For 300 ppm wheat the median risks for the Netherlands (9.1%) and the US (12.2%) are in two different risk categories (10-25% and 5-10%) and is considered a relevant difference according to method 2. For the highest allergen concentration of 10,000 ppm, the risks are significantly different for both mustard and wheat, but not relevant according to both methods. The current examples show that large differences in consumption amounts between the countries do not inevitably lead to relevant risk differences.

3.4. Comparison of risk assessment outcomes based on food intake data of the United States and the Netherlands

For nine food groups, no significant differences in risk assessment outcomes were found for any of the concentrations (i.e. the confidence intervals were overlapping). For 40 food groups, significant differences were found for at least one comparison across the range of allergenic foods and concentrations. The non-significant and significant risk differences are depicted in the heatmaps in Fig. 2 and Supplementary Tables.

Fig. 2 illustrates heatmaps depicting the non-significant (i.e. overlapping confidence intervals) and significant (i.e. no overlap in confidence intervals) risk differences as indicated with white and colored boxes, respectively, and the non-relevant (i.e. differences smaller than a factor of 1.5) and relevant (i.e. differences equal to or larger than a factor of 1.5) risk differences as indicated with striped and full coloring, respectively. Different colors indicate different magnitudes of category differences. The figure shows the results for three different concentrations of allergenic protein. Heatmaps for the other six concentrations are available in the Supplementary Tables.

Fig. 2A shows that for a concentration of 3 ppm, risk differences were not significant for the majority of food groups (n = 32) for any of the allergenic foods (white boxes). For 17 food groups significant differences were present, as indicated by the striped and full shaded boxes. However, not all of the significant differences were considered relevant, as indicated with the blue boxes.

3.4.1. Comparison using method 1: the cutoff of a factor of 1.5

Risk differences of a factor ≥1.5 were present for 8 food groups for at least one of the allergenic foods (fully shaded boxes). The differences were mainly seen for allergenic foods with the highest population sensitivity, i.e. mustard to cashew (see also heatmap for 1 ppm in Supplementary Table A). Here, the relative difference between median risks was large due to the low risks (e.g. 1% vs. 2%; factor 2 difference), naturally present at low concentrations, such as 1 and 3 ppm. The risks for allergenic foods with lower population sensitivity were generally between 0% and 5% at low concentrations with overlapping risk percentile intervals and thus were not significant.

The heatmap for the concentration of 300 ppm (Fig. 2B) shows significant risk differences for 32 food groups. Yet, most were below a

Table 1
Food consumption amounts and risk assessment outcome for 'Pancakes and waffles' for the US and the Netherlands. Mustard and wheat are used as example allergenic foods at concentrations of 1 ppm, 300 ppm and 10,000 ppm.

US (NHANES)						The Netherlands (DNFCS)				
Food consumption 'Pancakes and waffles' (gram)										
n				Median	2.5-97.5 percentile	n		Median	2.5-97.5 percentile	
1380				90.3	20.0-286.5	257		30.0	10.0-430.0	
	US		**NL**							
	Risk assessment outcome for 'Pancakes and waffles' (%)					**Evaluation method 1**		**Evaluation method 2**		
	Median risk	2.5-97.5 percentile	Median risk	2.5-97.5 percentile	Significant difference in risk	Median factor difference	≥1.5 factor difference	Risk cat. US[b]	Risk cat. NL[b]	Different risk categories[a]
1 ppm										
Mustard	1.7	(1.5-1.9)	1.3	(1.1-1.6)	no	1.31	NA[c]	1-5%	1-5%	NA[c]
Wheat	0.1	(0.0-0.1)	0.0	(0.0-0.1)	no	-	NA[c]	<1%	<1%	NA[c]
300 ppm										
Mustard	48.9	(48.0-50.0)	40.3	(38.5-41.9)	yes	1.21	no	25-50%	25-50%	no
Wheat	12.2	(11.5-12.8)	9.1	(8.3-10.0)	yes	1.34	no	10-25%	5-10%	yes
10,000 ppm										
Mustard	99.6	(99.4-99.7)	95.3	(94.2-96.3)	yes	1.05	no	>50%	>50%	no
Wheat	78.7	(77.7-79.5)	65.6	(63.2-68.0)	yes	1.20	no	>50%	>50%	no

[a] Relevant risk difference: median risks for the US and the Netherlands are in different risk categories.
[b] Risk categories: <1%, 1-5%, 5-10%, 10-25%, 25-50%, >50%.
[c] The risks difference is not significant, thus the relevance is not determined.



Fig. 2. Example of the results of the probabilistic risk assessment for allergenic protein concentrations of 3 ppm (A), 300 ppm (B) and 3000 ppm (C). The 49 food groups are presented on the y-axis and the 14 allergenic foods on the x-axis. Two analysis methods are presented in the heatmaps, in a way that the methods can be analyzed separately as well as combined. Risk differences analyzed according to the 1.5 factor difference between the risk medians (method 1) are visualized by striped or full shading. Analysis by the risk categories (method 2) is visualized by different colors. Blue colored cells indicate that the median risks of the two countries are in the same risk category and are therefore considered not relevant according to the category criterion. Red colored cells indicate that the median risks of the two countries are in different risk categories and therefore considered potentially relevant. The intensity of the red colored cells indicate the magnitude of the difference between the risk medians: the cells are colored light red if the median risks are in adjacent risk categories, darker shaded red if the median risks span 2 categories, and darkest red for a span of 3 categories. In case of a span of 2 or 3 categories, median risk differences were always $\geq$1.5 (thus striped boxes do not occur in different colors of red). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)



Fig. 2. (*continued*).

factor of 1.5 (indicated with the striped shaded boxes). Risk differences of a factor of 1.5 or more were present for 10 food groups (indicated with the fully shaded boxes), for all allergenic foods. The 10 food groups include those that showed relevant risk differences for the concentrations of 1 and 3 ppm. For these food groups, except for 'Chewing gum' and 'Sauces used as condiments and dessert sauces', the median consumption amounts of the US and the Netherlands differed considerably, i.e. at least around a factor 2 (see Table 2). For 'Chewing gum', the relevant risk differences are explained by the large difference in intake distribution between the countries for this food group, along with the low risks that cause large relative risk differences. Compared to other food groups with low intake amounts, but for which the risk difference was below a factor of 1.5 ('Sugar' and 'Coffee creamer'), the distribution of intake levels between the countries was more similar compared to 'Chewing gum'. This resulted in non-significant differences for 'Sugar' and 'Coffee creamer'. For a few food groups, the median food intake levels were above a factor 2, but showed no relevant risk differences (e.g. 'Syrups', 'Chestnut paste and coconut milk', 'Cheese'). Also for these food groups, the food intake distributions were quite similar between the countries, resulting in non-significant differences. The heatmap of



Fig. 2. (*continued*).

Table 2
Overview of median food intake levels and occurrence of relevant differences in risk assessment outcomes for the US and the Netherlands per food group.

Food group	Median food intake US (g)	Food intake distribution US 2.5th and 97.5th percentile (g)	Median food intake Netherlands (g)	Food intake distribution Netherlands 2.5th and 97.5th percentile (g)	Statistically significant risk difference ($p < 0.05$)[a]	Relevant risk difference according method 1[a]	Relevant risk difference according to method 2[a]	Relevant risk differences according to the methods combined[b]
1. Supplements	35.0	6.0-149.1	2.0	1.0-13.0	yes	yes	yes	yes
2. Alcoholic drinks, alcohol above 15 percent	146.5	27.8-990.0	72.8	0.9-329.1	yes	yes	yes	yes
3. Drinks without alcohol, excl. syrup	1000.0	322.4-4147.5	750.0	288.8-1881.3	yes	yes	yes	-
4. Sandwich and pizza	224.0	39.0-712.5	120.0	57.2-284.4	yes	yes	yes	yes
5. Meal replacements	248.0	19.4-642.2	34.1	11.6-427.4	yes	yes	yes	yes
6. Herbs and spices mixes, bouillon, cubes, yeast extract	1.0	0.2-23.7	8.8	0.5-65.4	yes	Yes	yes	yes
7. Savory salads	91.0	10.2-316.4	40.0	10.0-157.9	yes	yes	yes	yes
8. Meat imitates	28.0	1.2-211.5	83.4	17.7-155.8	yes	yes	yes	yes
9. Bread, bread rolls and bread doughs	58.9	24.0-222.0	105.0	45.0-242.0	yes	yes	yes	-
10. Cream and coffee milk	30.0	4.4-143.8	16.0	4.5-81.0	yes	yes	yes	yes
11. Cereal bars	37.0	21.0-100.0	25.0	22.0-40.0	yes	yes	yes	-
12. Chewing gum	2.8	2.8-22.4	2.0	1.0-8.0	yes	yes	yes	yes
13. Butter or halvarine or margarine	9.5	1.2-38.2	18.0	3.0-48.0	yes	yes	yes	yes
14. Soups	370.0	88.0-1217.5	259.0	26.2-660.0	yes	-	yes	-
15. Beer	720.0	205.1-4320.0	600.0	245.0-3600.0	yes	-	yes	-
16. Potato product	114.0	17.8-386.0	169.5	41.8-410.0	yes	-	yes	-
17. Fish products	113.0	13.8-477.9	90.0	8.4-280.0	yes	-	yes	-
18. Cakes	93.0	15.9-364.8	80.0	25.0-200.0	yes	-	yes	-
19. Eggs	76.0	16.5-152.9	50.0	4.5-135.0	yes	-	yes	-
20. Sauces used as condiments and dessert sauces	31.2	2.6-223.1	25.0	2.5-111.6	yes	-	yes	-
21. Breakfast products eaten unprocessed	52.5	13.7-172.3	40.0	9.9-85.0	yes	-	yes	-
22. Fruit and vegetables, processed	108.0	8.3-415.0	160.0	14.7-373.2	yes	-	yes	-
23. Milk and milk products consumed with a spoon	170.0	30.6-408.5	201.6	48.9-424.9	yes	-	yes	-
24. Pancakes and waffles	90.3	20.0-286.5	30.0	10.0-430.0	yes	-	yes	-
25. Meat	123.0	23.1-426.0	112.0	24.0-344.0	yes	-	yes	-
26. Cookies	36.0	6.0-156.0	30.0	8.0-100.0	yes	-	yes	-
27. Crackers, crisp bread, rusk and toast	20.0	1.5-97.9	20.0	2.5-60.0	yes	-	yes	-
28. Sweet sandwich filling	18.1	3.1-83.1	20.0	5.0-80.0	yes	-	yes	-
29. Coffee creamer	5.9	1.0-35.2	4.0	0.8-12.0	yes	-	yes	-
30. Vegetable oils and animal fat	9.0	1.1-54.0	12.4	1.1-47.0	yes	-	yes	-
31. Cheese	28.4	3.5-1760.0	42	12.0-135.4	yes	-	yes	-
32. Ice cream	114.0	19.1-400.0	86.0	35.6-203.1	yes	-	yes	-
33. Breakfast products, porridge	234.0	61.5-660.0	200.0	69.7-533.0	-	-	-	-
34. Milk powder and cocoa powder	5.5	0.4-83.8	6.6	1.0-43.6	-	-	-	-
35. Fruit and vegetables, unprocessed	149.0	11.1-572.0	144.5	12.0-402.7	-	-	-	-
	220.5	14.8-947.2	240.0	69.6-657.3	yes	-	-	-

(*continued on next page*)

Table 2 (*continued*)

Food group	Median food intake US (g)	Food intake distribution US 2.5th and 97.5th percentile (g)	Median food intake Netherlands (g)	Food intake distribution Netherlands 2.5th and 97.5th percentile (g)	Statistically significant risk difference ($p < 0.05$)[a]	Relevant risk difference according method 1[a]	Relevant risk difference according to method 2[a]	Relevant risk differences according to the methods combined[b]
36. Alcoholic drinks, alcohol below 15 percent								
37. Legumes	126.5	11.1-453.6	115.7	14.7-327.7	-	-	-	-
38. Milk and milk products for drinking	259.2	15.2-906.2	270.0	15.0-679.8	-	-	-	-
39. Syrups	40.0	3.3-93.1	18.0	1.7-124.7	-	-	-	-
40. Small sweets, sweet confectionary specified	17.0	2.0-155.8	16.0	2.0-157.2	yes	-	-	-
41. Sauces, savory, chutneys and pickles	60.8	2.7-322.8	53.9	6.2-227.5	-	-	-	-
42. Fried or warm snacks	64.0	13.1-312.0	70.0	30.0-210.8	yes	-	-	-
43. Potato and other starch based chips	32.8	5.8-163.9	40.0	5.0-158.0	yes	-	-	-
44. Chocolate and chocolate products	31.2	5.0-120.0	24.0	5.0-130.4		-	-	-
45. Chestnut paste and coconut milk	37.0	17.3-282.1	71.0	9.9-199.9	-	-	-	-
46. Peanuts, nuts and dried fruits	36.2	3.0-183.8	30.0	2.4-159.9	-	-	-	-
47. Peanut butter	21.3	5.3-128.0	20.0	10.0-76.7	yes	-	-	-
48. Pasta, rice, couscous and other grains	158.0	18.2-523.4	167.0	34.7-428.1	yes	-	-	-
49. Sugar	8.3	1.0-50.0	8.0	1.0-40.8	yes	-	-	-

[a] For at least one of the allergenic foods across the entire range of allergenic protein concentrations.
[b] 'Yes': Food groups with risk outcomes that both have a median risk difference of a factor ≥1.5 *and* are in different risk categories across the entire range of allergenic protein concentrations (red, full shaded boxes in heatmaps), as further explained in paragraph 3.5.

100 ppm is comparable to the heatmap of 300 ppm (see Supplementary Table D).

At a concentration of 3000 ppm (Fig. 2C) more significant risk differences were present when using the factor of 1.5 criterion compared to the concentrations of 100 and 300 ppm. However, less food groups show relevant risk differences, i.e. n = 8 (vs. n = 11 for 100 ppm). This is due to the increasing median absolute risks coming with increasing concentrations, leading to lower relative risk differences. So, for the three food groups that show relevant risk differences for the concentration of 100 ppm but not for 3000 ppm ('Cream and coffee milk', 'Butter or halvarine or margarine', 'Sauces used as condiments and dessert sauces'), the differences were relatively large at 100 ppm due to the low risk outcomes (e.g. 0.4% vs. 0.7%, thus considered to be relevant), whereas the risk difference for the same allergenic food at 3000 ppm was below the factor of 1.5 (e.g. 8.6% vs. 12.8%). The heatmaps of 1000 and 10,000 ppm are comparable to the heatmap of 3000 ppm (see Supplementary Tables E and F).

An overview of the food groups for which relevant risk differences were found for at least one of the allergenic foods according to the factor-1.5-criterion is presented in Table 2.

3.4.2. *Comparison using method 2: risk categories*

In Fig. 2A, the risk comparison based on risk categories for a concentration of 3 ppm is also presented. The risk category criterion is visualized in the heatmaps by color, where blue boxes are risks within the same risk category, and red boxes with increasing intensity indicate the increasing distance over the risk categories. At 3 ppm, 41 of the 49 food groups showed no relevant risk differences for any of the allergenic foods, i.e. no red boxes (striped and full shaded) are present in the heatmap for these food groups. Thus, for 8 food groups relevant risk differences (red boxes) were found across the range of allergenic foods. There is no pattern visible in the number of food groups with relevant risk differences across the types of allergenic foods. In the heatmap for 3 ppm, only the lightest shade of red is present, indicating that all the potentially relevant differences span one risk category. The heatmap for the concentration of 1 ppm (see Supplementary Table A) is more or less similar to the heatmap of 3 ppm, except that less relevant differences were found, because most risks outcomes were below <1% for both US and the Netherlands.

Fig. 2B shows the risk assessment results for 300 ppm. Relevant differences were found for 28 food groups for at least one, but usually multiple allergenic foods. It can be seen that the risk differences, if relevant, span 1 risk category for almost all of the outcomes (lightest shade of red). Only for 'Supplements', several risk differences span two categories (middle shade of red). This is not surprising considering that the median 'Supplements' intake amounts for the US and the Netherlands are respectively 35 g and 2 g, i.e. the intake amount between the countries differs 17.5-fold (see also Discussion). The heatmap for 100 ppm (see Supplementary Table D) is quite similar to the 300 ppm heatmap. A few less relevant differences were found for the concentration of 100 ppm.

Fig. 2C shows the risk assessment results for a concentration of 3000 ppm. Due to the high concentration, most risks are in the two highest risk categories, i.e. 25-50% and >50%. Consequently, the majority of the risk differences are either not significant or significant but in the same risk category. However, for 27 food groups, at least one potentially relevant difference was found across the different allergenic foods (red boxes). In most of these cases the lowest median risk is in category 25-

50% and the highest in category >50%. Almost all relevant risk differences span one category. For 'Supplements' and 'Herbs and spice mixes, bouillon cubes, yeast extract', the risk differences for a few allergenic sources span 2 or even 3 categories, which are indicated in the heatmap as respectively the middle and darkest shade of red. This phenomenon is due to the high difference in median intake amounts (at least 8-fold) of low-consumption products.

Several general conclusions can be drawn from the results described above. The number of relevant risk differences is low for the lower allergen concentrations (1 ppm and 3 ppm), but substantial for the concentrations of 100 ppm-10,000 ppm (n = 25-31). The total of food groups for which a relevant risk difference was found (n = 32) is presented in Table 2. For all allergenic foods there were multiple relevant risk differences across the total range of concentrations.

3.5. Comparison based on a combination of the factor 1.5 and risk category criterion

The heatmaps enable us to analyze the two evaluation methods in combination. Frequently, the risk category method provides potentially relevant differences which are less than a factor 1.5 (striped red colored cells). In these cases, the risks are often close to the border of a category, e.g. the median risk for the US population might be 24%, and the median risk for the Netherlands population 26%. Although these risks are close, the risk category strategy defines the difference as relevant because they are in different categories. However, when applying the factor-1.5 method, the difference would not be considered relevant. On the other hand, for the lower concentrations (1 ppm and 3 ppm), risks were frequently considered relevant by the factor 1.5 method because of the small absolute risks, e.g. 0.1% vs. 0.3%. The risk category strategy would not mark this as a relevant difference, as they are both in the category of <1%. The integration of both methods, which identifies risk differences for which median risks differ a factor 1.5 or more and are in different risk categories (red, full shaded boxes), likely gives the best overview of potentially relevant differences (Table 2). To note, in this way it is possible that food groups for which is indicated that both method 1 and method 2 show relevant risk differences in Table 2, could be not relevant according to the methods combined because the two relevant risk differences never occur for the risk outcomes (e.g. 'Cereal bars'). Table 3 provides an overview of the number of food groups for which potentially relevant differences were found according to the methods combined. Relevant differences were found for 5 to 9 of the food groups depending on the assumed concentration of allergenic protein. In total, relevant differences were present for 10 food groups when the two methods were integrated (Table 2).

4. Discussion

We systematically assessed the impact of differences in intake levels of food items between the North American population and a European population in terms of differences in risk assessment outcomes of probabilistic modelling for allergenic substances. Risks were calculated for a wide range of simulated allergen concentrations using threshold distribution data from the most recent and complete threshold database (Remington et al., 2020). For 20% (10 out of 49) of the food groups, calculated risks appeared to differ too much to unconditionally consider them comparable between the US and the Netherlands, due to differences in intake amounts, at allergen concentrations that have been found to be unintentionally present in food products (Allen and Taylor, 2018). Therefore, we conclude that it should be discouraged to use food consumption data from one country for another country in food allergen risk assessment without critical consideration. As a default, we recommend the use of country specific data or to develop and use an overarching food group intake table based on the highest intake figure for each food group of the countries if a risk assessment is to cover several countries.

Birot et al. (2018) combined food consumption data from three countries in Europe with the final aim to create an overarching food intake database for the purpose of allergen risk assessment. In this study it was seen that several product groups showed large risk differences due to food intake differences, and it was recommended to define food groups with country specific consumption. This study also stipulated the relevance of comparing consumption patterns to determine if food intake is sufficiently comparable for risk assessment purposes, even for countries within the same continent.

Our results show that the method of evaluation determines the conclusion of the outcome. From a risk management perspective, where risk-based limit values are used frequently to determine the necessity of actions, the risk categories were one way to describe and visualize the data. Although partly selected based on practice or recommendations from others (1% from the VITAL approach and 5% from an opinion of Scientific Committee of the Belgian Federal Agency for the Safety of the Food Chain), the cutoff values for the various categories we selected are rather arbitrary. However, selection of other cutoff values would have resulted in the same conclusion. The limitation of the risk category method is that the cutoffs of the risk categories led to differences marked as potentially relevant while the risks were still quite similar. The factor 1.5-methods is less biased in that sense, but is limited by marking risk differences as potentially relevant at the low concentration ranges, while actually being very similar. From our perspective, risk differences are most legitimately defined as relevant when both methods determine the risk differences potentially relevant.

Both methods as well as the combined approach led to the same overall conclusion, namely that differences in calculated risks between the US and the Netherlands are frequent and may be too large to allow the assumption that these are non-relevant. Therefore, for food allergen risk assessment, we recommend to use country specific data or to develop and use an overarching food group intake table based on highest intake values if a risk assessment is to cover several countries.

In our study, risks from intakes of some food products within certain food groups were found to differ considerably between the US and the Netherlands. In retrospect, we found that this sometimes was due to clear differences in the type of products included in a food group. This was for example the case with the food group 'Supplements'. In the US, products such as protein supplements, lecithin and bee pollen were primarily present in this food group. In the Dutch survey, mostly small supplements such as vitamins pills, folic acid and other elements were present in the database. As protein supplements are usually consumed in larger quantities than e.g. vitamins, US supplement intake levels were considerably higher compared to the Netherlands. Thus, although the food products were correctly allocated in the food group 'Supplements', the different range of products used between the countries caused large intake differences, and consequently large risk differences. However, such substantial differences in types of products within food groups occurred only incidental and has not influenced the overall conclusion from the study, i.e. that potentially relevant differences in food intake levels may occur among countries too often and that these differences

Table 3
Number of food groups for which relevant differences were found according to the combined method 1 and method 2. The detailed results can be viewed in the heatmaps (Fig. 2 and Supplementary Tables).

Allergenic protein concentration (ppm)	n of 49 food groups
1	5
3	5
10	7
30	9
100	9
300	9
1000	8
3000	8
10,000	7

may be too large to ignore in food allergen risk assessment.

In the present study we focused on the intake distributions of both countries. When performing a risk assessment for a specific product, other aspects should be taken into account, such as the threshold dose distribution. It should be noted here that small differences in the 14 threshold distributions (e.g. milk, egg, peanut (Houben et al., 2020)) resulted in similar trends for risk outcomes.

In view of the conclusion that differences in food product intakes between the US and the Netherlands are too frequent and too large to ignore in food allergen risk assessment, country specific data need to be used. However, for some purposes, particularly in view of the international nature of food production and trade, an approach covering various countries or regions would be of great value. An option would be to develop and use an overarching table of intake data per eating occasion based on the worst case of multiple countries that it should cover. Such an overarching food intake table could be based on food intake databases, preferably from various countries and continents, and allow the selection of appropriate food intake figures for the calculation of for instance action levels for precautionary allergen labelling and account for possible differences in food intake among the countries and continents. Currently, there is no guidance for the selection of appropriate intake figures for food allergen risk assessment and risk management purposes. However, to obtain and select appropriate intake data and decide on a correct portion size to use for these purposes, specific expert knowledge is needed. Inadequate choices may cause wrong risk assessments, while diversity of available data can result in different, individual interpretations and subsequently in different decisions for similar situations and cause equal products to be judged differently in terms of assumed risks and consequently being managed differently.

Previous research has shown that creation of a pan European intake database is possible for broader toxicological assessments (EFSA, 2011). Similarly, a case study with three European countries has shown that it would be possible to create a pan-western world food intake table specifically for food allergen risk assessment (Birot et al., 2018). An overarching table accompanied with a guidance or tool for the selection of appropriate food intake figures for food allergy risk assessment or the calculation of action levels would support reliability and harmonization. This should preferably be developed at a super- or international level.

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CRediT authorship contribution statement

Marie Y. Meima: Writing - original draft, Investigation, Formal analysis, Methodology, Visualization. **W. Marty Blom:** Conceptualization, Writing - review & editing, Investigation, Visualization, Funding acquisition, Supervision. **Joost Westerhout:** Visualization, Software, Formal analysis, Writing - review & editing. **Astrid G. Kruizinga:** Investigation, Writing - review & editing, Methodology, Visualization, Project administration. **Benjamin C. Remington:** Conceptualization, Writing - review & editing, Investigation, Methodology, Visualization. **Geert F. Houben:** Conceptualization, Investigation, Methodology, Funding acquisition, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fct.2021.112006.

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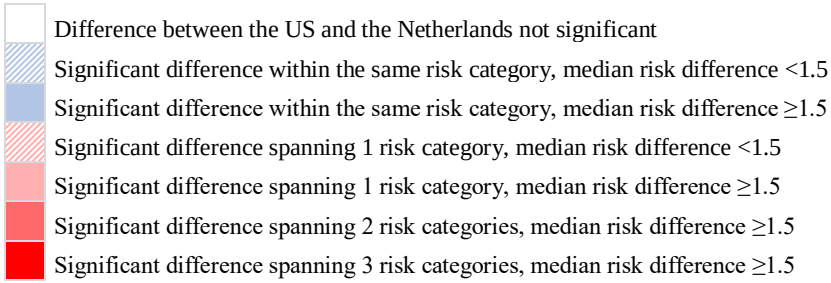
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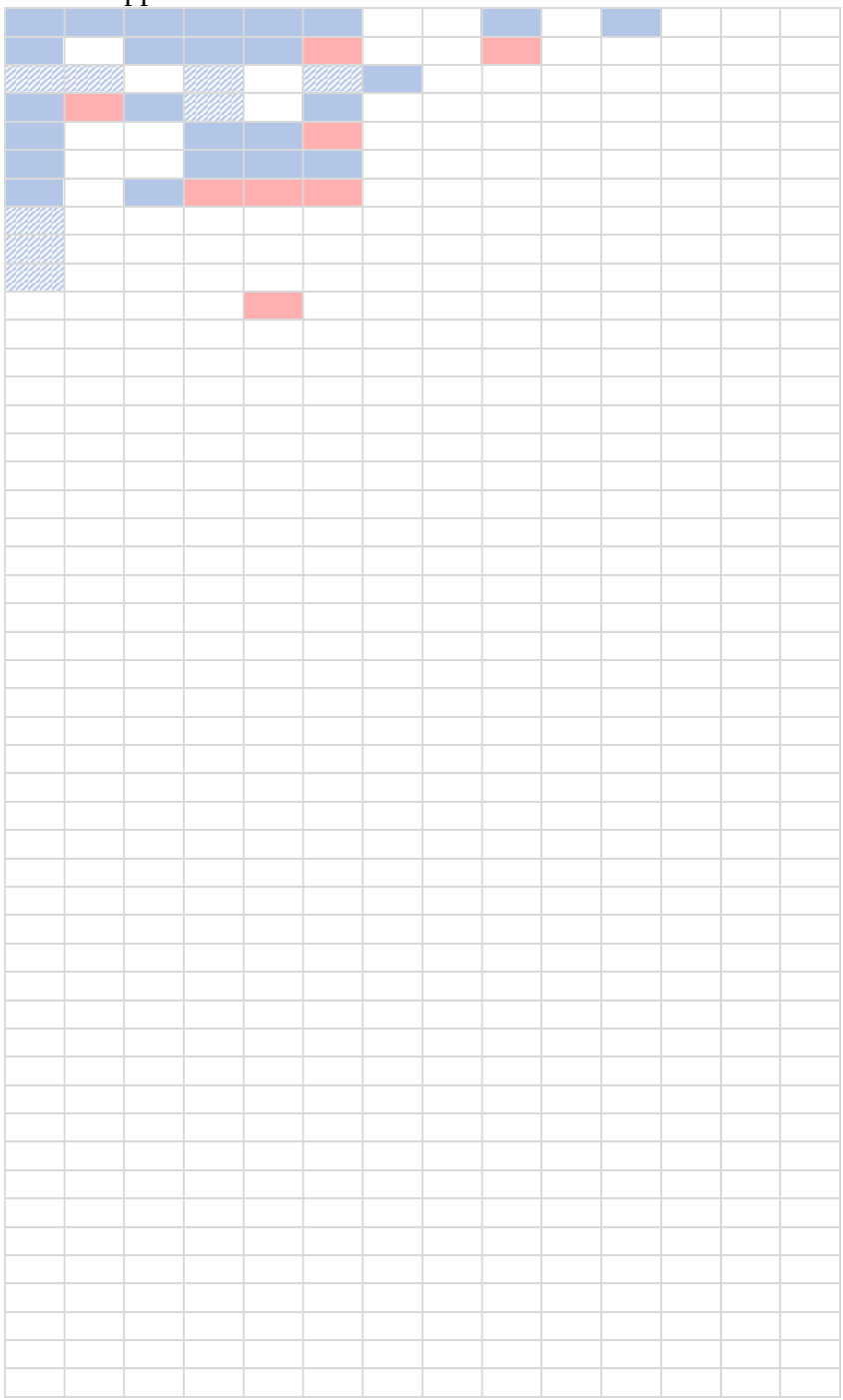
Supplemental

Heatmaps for the allergenic protein concentrations of 1, 10, 30, 100, 1000 and 10,000 ppm (A-F). A detailed description is present in Figure 2 of the manuscript.

Legend.



A. 1 ppm


Supplements
Alcoholic drinks, alcohol above 15 percent
Drinks without alcohol (excl. syrup)
Sandwich and pizza
Meal replacements
Herbs and spices mixes, bouillon cubes, yeast extract
Savoury salads
Soups
Beer
Potato product (excl. powder)
Meat imitates
Fish products
Bread, bread rolls and bread doughs
Ice cream
Cream and coffee milk
Cakes (including pastry)
Cereal bars
Eggs
Sauces used as condiments and dessert sauces
Chewing gum
Breakfast products eaten unprocessed
Fruit and vegetables, processed
Milk and milk products consumed with a spoon
Pancakes and wafles
Breakfast products, porridge
Butter or halvarine or margarine
Milk powder and cocoa powder
Fruit and vegetables, unprocessed
Alcoholic drinks, alcohol below 15 percent
Meat
Cookies (biscuits)
Crackers, crisp bread, rusk and toast
Legumes
Milk and milk products for drinking
Sweet sandwich filling
Syrups
Coffee creamer
Vegetable oils and animal fat
Small sweets - sweet confectionary specified
Sauces , savory, chutneys and pickles
Fried or warm snacks
Potato and other starch based chips
Chocolate and chocolate products
Chestnut paste and coconut milk
Cheese
Peanuts, nuts and dried fruits
Peanut butter
Pasta, rice, couscous and other grains
Sugar
Mustard
Egg
Milk
Celery
Walnut
Cashew
Peanut
Wheat
Sesame
Lupin
Hazelnut
Fish
Soy
Shrimp

B. 10 ppm


Supplements
Alcoholic drinks, alcohol above 15 percent
Drinks without alcohol (excl. syrup)
Sandwich and pizza
Meal replacements
Herbs and spices mixes, bouillon cubes, yeast extract
Savoury salads
Soups
Beer
Potato product (excl. powder)
Meat imitates
Fish products
Bread, bread rolls and bread doughs
Ice cream
Cream and coffee milk
Cakes (including pastry)
Cereal bars
Eggs
Sauces used as condiments and dessert sauces
Chewing gum
Breakfast products eaten unprocessed
Fruit and vegetables, processed
Milk and milk products consumed with a spoon
Pancakes and wafles
Breakfast products, porridge
Butter or halvarine or margarine
Milk powder and Cocoa powder
Fruit and vegetables, unprocessed
Alcoholic drinks, alcohol below 15 percent
Meat
Cookies (biscuits)
Crackers, crisp bread, rusk and toast
Legumes
Milk and milk products for drinking
Sweet sandwich filling
Syrups
Coffee creamer
Vegetable oils and animal fat
Small sweets - sweet confectionary specified
Sauces , savory, chutneys and pickles
Fried or warm snacks
Potato and other starch based chips
Chocolate and chocolate products
Chestnut paste and coconut milk
Cheese
Peanuts, nuts and dried fruits
Peanut butter
Pasta, rice, couscous and other grains
Sugar
Mustard
Egg
Milk
Celery
Walnut
Cashew
Peanut
Wheat
Sesame
Lupin
Hazelnut
Fish
Soy
Shrimp

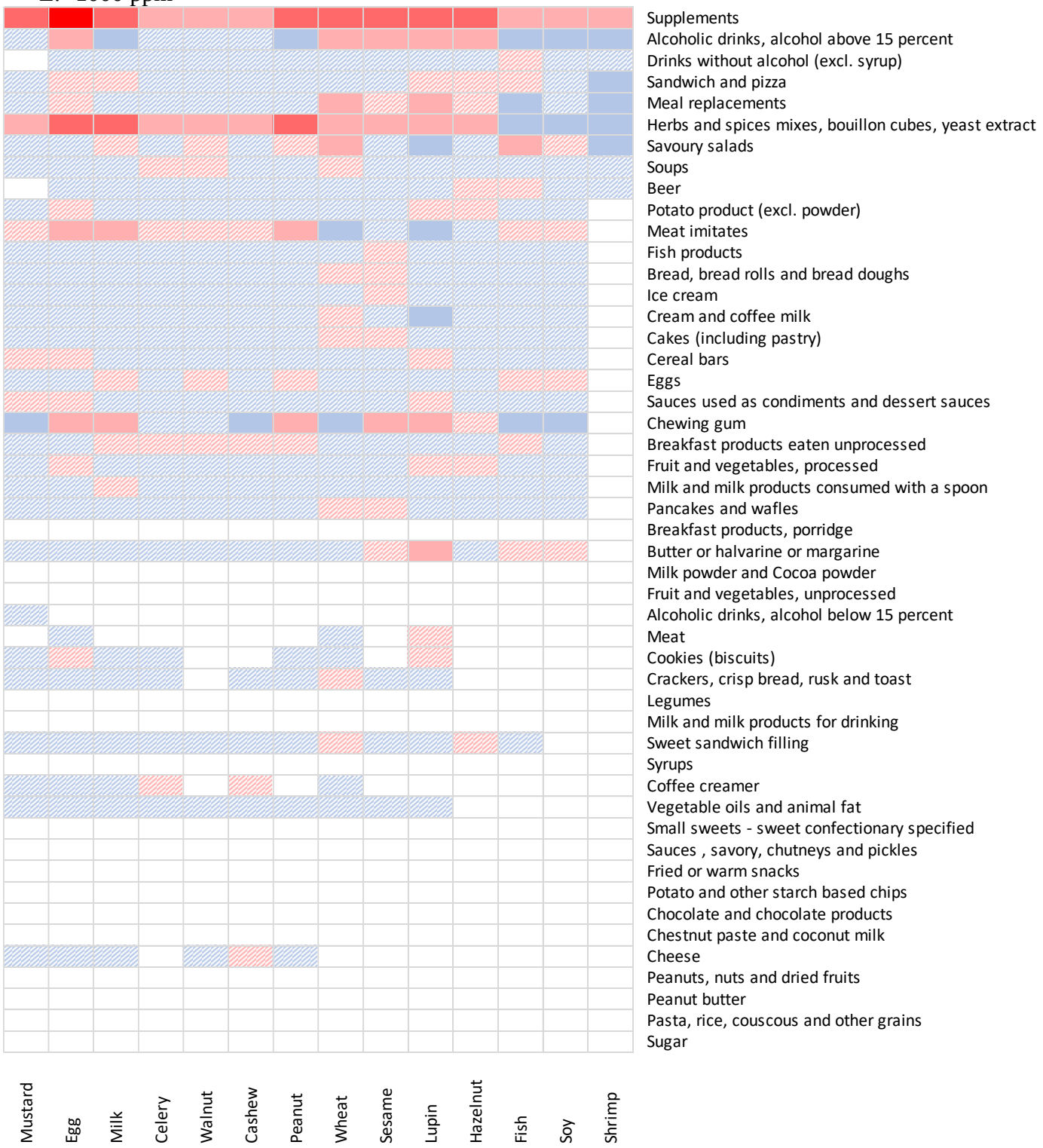
C. 30 ppm


Supplements
Alcoholic drinks, alcohol above 15 percent
Drinks without alcohol (excl. syrup)
Sandwich and pizza
Meal replacements
Herbs and spices mixes, bouillon cubes, yeast extract
Savoury salads
Soups
Beer
Potato product (excl. powder)
Meat imitates
Fish products
Bread, bread rolls and bread doughs
Ice cream
Cream and coffee milk
Cakes (including pastry)
Cereal bars
Eggs
Sauces used as condiments and dessert sauces
Chewing gum
Breakfast products eaten unprocessed
Fruit and vegetables, processed
Milk and milk products consumed with a spoon
Pancakes and wafles
Breakfast products, porridge
Butter or halvarine or margarine
Milk powder and Cocoa powder
Fruit and vegetables, unprocessed
Alcoholic drinks, alcohol below 15 percent
Meat
Cookies (biscuits)
Crackers, crisp bread, rusk and toast
Legumes
Milk and milk products for drinking
Sweet sandwich filling
Syrups
Coffee creamer
Vegetable oils and animal fat
Small sweets - sweet confectionary specified
Sauces , savory, chutneys and pickles
Fried or warm snacks
Potato and other starch based chips
Chocolate and chocolate products
Chestnut paste and coconut milk
Cheese
Peanuts, nuts and dried fruits
Peanut butter
Pasta, rice, couscous and other grains
Sugar
Mustard
Egg
Milk
Celery
Walnut
Cashew
Peanut
Wheat
Sesame
Lupin
Hazelnut
Fish
Soy
Shrimp

D. 100 ppm


Supplements
Alcoholic drinks, alcohol above 15 percent
Drinks without alcohol (excl. syrup)
Sandwich and pizza
Meal replacements
Herbs and spices mixes, bouillon cubes, yeast extract
Savoury salads
Soups
Beer
Potato product (excl. powder)
Meat imitates
Fish products
Bread, bread rolls and bread doughs
Ice cream
Cream and coffee milk
Cakes (including pastry)
Cereal bars
Eggs
Sauces used as condiments and dessert sauces
Chewing gum
Breakfast products eaten unprocessed
Fruit and vegetables, processed
Milk and milk products consumed with a spoon
Pancakes and wafles
Breakfast products, porridge
Butter or halvarine or margarine
Milk powder and Cocoa powder
Fruit and vegetables, unprocessed
Alcoholic drinks, alcohol below 15 percent
Meat
Cookies (biscuits)
Crackers, crisp bread, rusk and toast
Legumes
Milk and milk products for drinking
Sweet sandwich filling
Syrups
Coffee creamer
Vegetable oils and animal fat
Small sweets - sweet confectionary specified
Sauces , savory, chutneys and pickles
Fried or warm snacks
Potato and other starch based chips
Chocolate and chocolate products
Chestnut paste and coconut milk
Cheese
Peanuts, nuts and dried fruits
Peanut butter
Pasta, rice, couscous and other grains
Sugar
Mustard
Egg
Milk
Celery
Walnut
Cashew
Peanut
Wheat
Sesame
Lupin
Hazelnut
Fish
Soy
Shrimp

E. 1000 ppm


Supplements
Alcoholic drinks, alcohol above 15 percent
Drinks without alcohol (excl. syrup)
Sandwich and pizza
Meal replacements
Herbs and spices mixes, bouillon cubes, yeast extract
Savoury salads
Soups
Beer
Potato product (excl. powder)
Meat imitates
Fish products
Bread, bread rolls and bread doughs
Ice cream
Cream and coffee milk
Cakes (including pastry)
Cereal bars
Eggs
Sauces used as condiments and dessert sauces
Chewing gum
Breakfast products eaten unprocessed
Fruit and vegetables, processed
Milk and milk products consumed with a spoon
Pancakes and wafles
Breakfast products, porridge
Butter or halvarine or margarine
Milk powder and Cocoa powder
Fruit and vegetables, unprocessed
Alcoholic drinks, alcohol below 15 percent
Meat
Cookies (biscuits)
Crackers, crisp bread, rusk and toast
Legumes
Milk and milk products for drinking
Sweet sandwich filling
Syrups
Coffee creamer
Vegetable oils and animal fat
Small sweets - sweet confectionary specified
Sauces , savory, chutneys and pickles
Fried or warm snacks
Potato and other starch based chips
Chocolate and chocolate products
Chestnut paste and coconut milk
Cheese
Peanuts, nuts and dried fruits
Peanut butter
Pasta, rice, couscous and other grains
Sugar
Mustard
Egg
Milk
Celery
Walnut
Cashew
Peanut
Wheat
Sesame
Lupin
Hazelnut
Fish
Soy
Shrimp

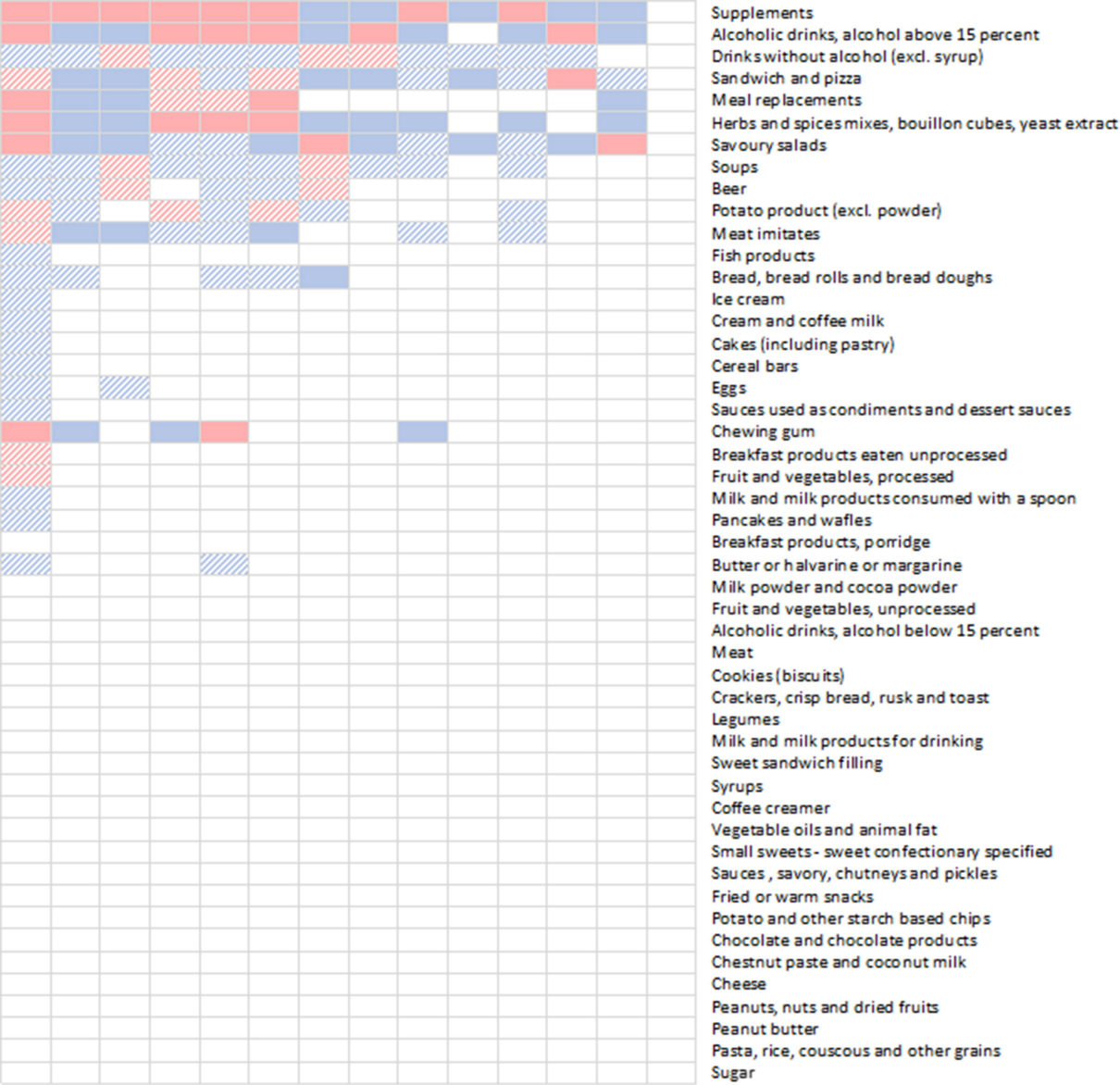
F. 10,000 ppm


Supplements
Alcoholic drinks, alcohol above 15 percent
Drinks without alcohol (excl. syrup)
Sandwich and pizza
Meal replacements
Herbs and spices mixes, bouillon cubes, yeast extract
Savoury salads
Soups
Beer
Potato product (excl. powder)
Meat imitates
Fish products
Bread, bread rolls and bread doughs
Ice cream
Cream and coffee milk
Cakes (including pastry)
Cereal bars
Eggs
Sauces used as condiments and dessert sauces
Chewing gum
Breakfast products eaten unprocessed
Fruit and vegetables, processed
Milk and milk products consumed with a spoon
Pancakes and wafles
Breakfast products, porridge
Butter or halvarine or margarine
Milk powder and Cocoa powder
Fruit and vegetables, unprocessed
Alcoholic drinks, alcohol below 15 percent
Meat
Cookies (biscuits)
Crackers, crisp bread, rusk and toast
Legumes
Milk and milk products for drinking
Sweet sandwich filling
Syrups
Coffee creamer
Vegetable oils and animal fat
Small sweets - sweet confectionary specified
Sauces , savory, chutneys and pickles
Fried or warm snacks
Potato and other starch based chips
Chocolate and chocolate products
Chestnut paste and coconut milk
Cheese
Peanuts, nuts and dried fruits
Peanut butter
Pasta, rice, couscous and other grains
Sugar
Mustard
Egg
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Sesame
Lupin
Hazelnut
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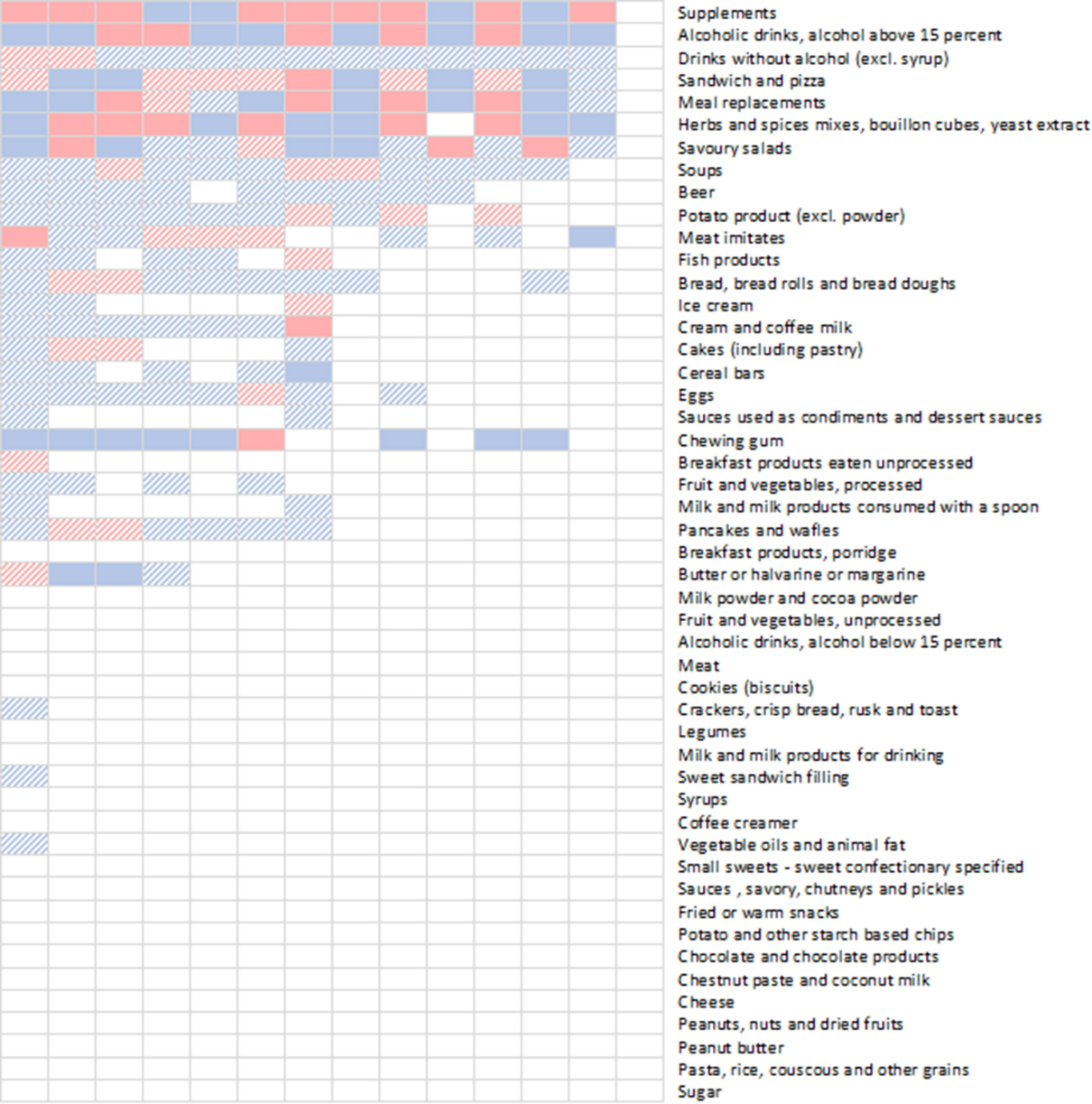

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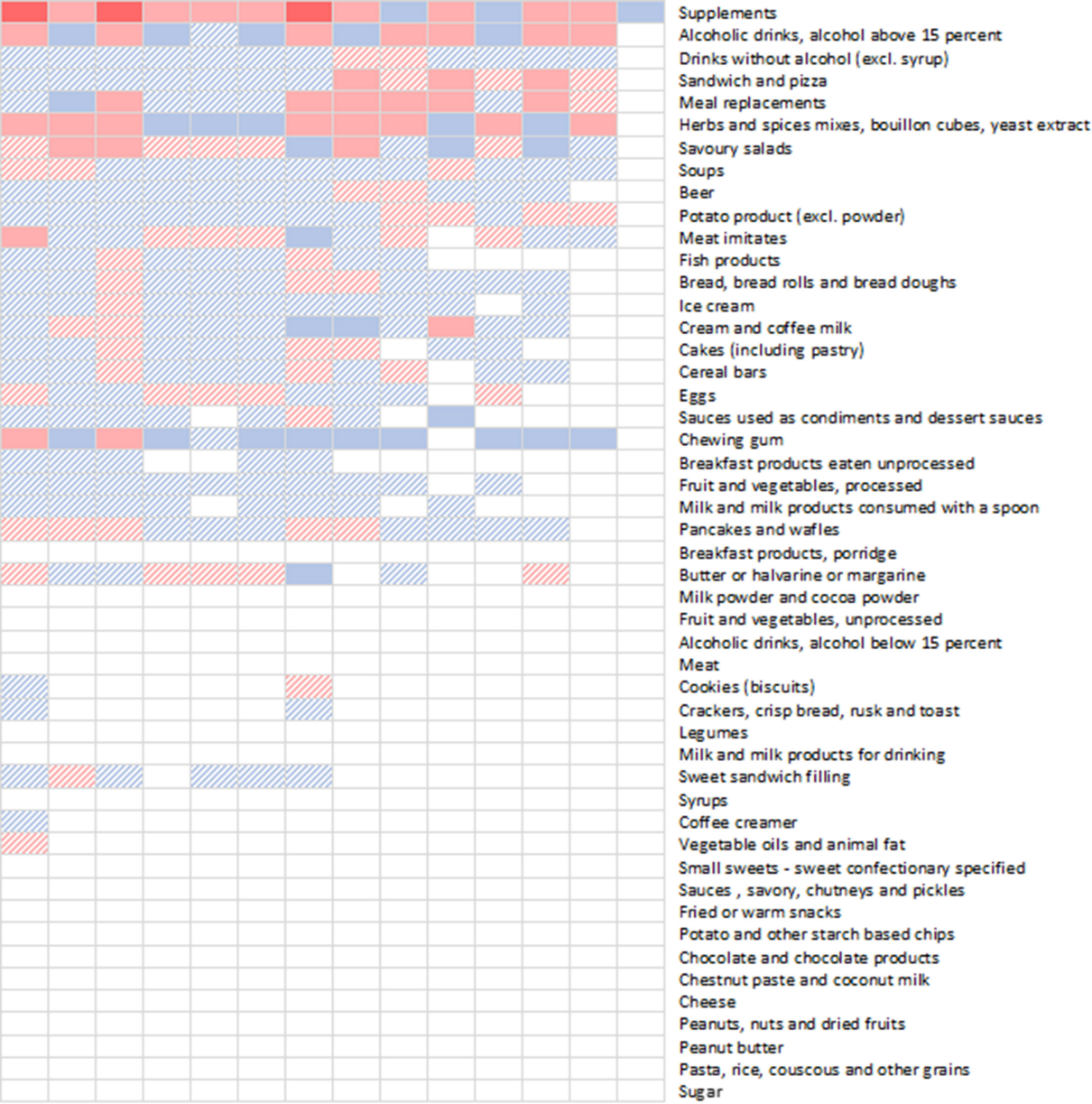

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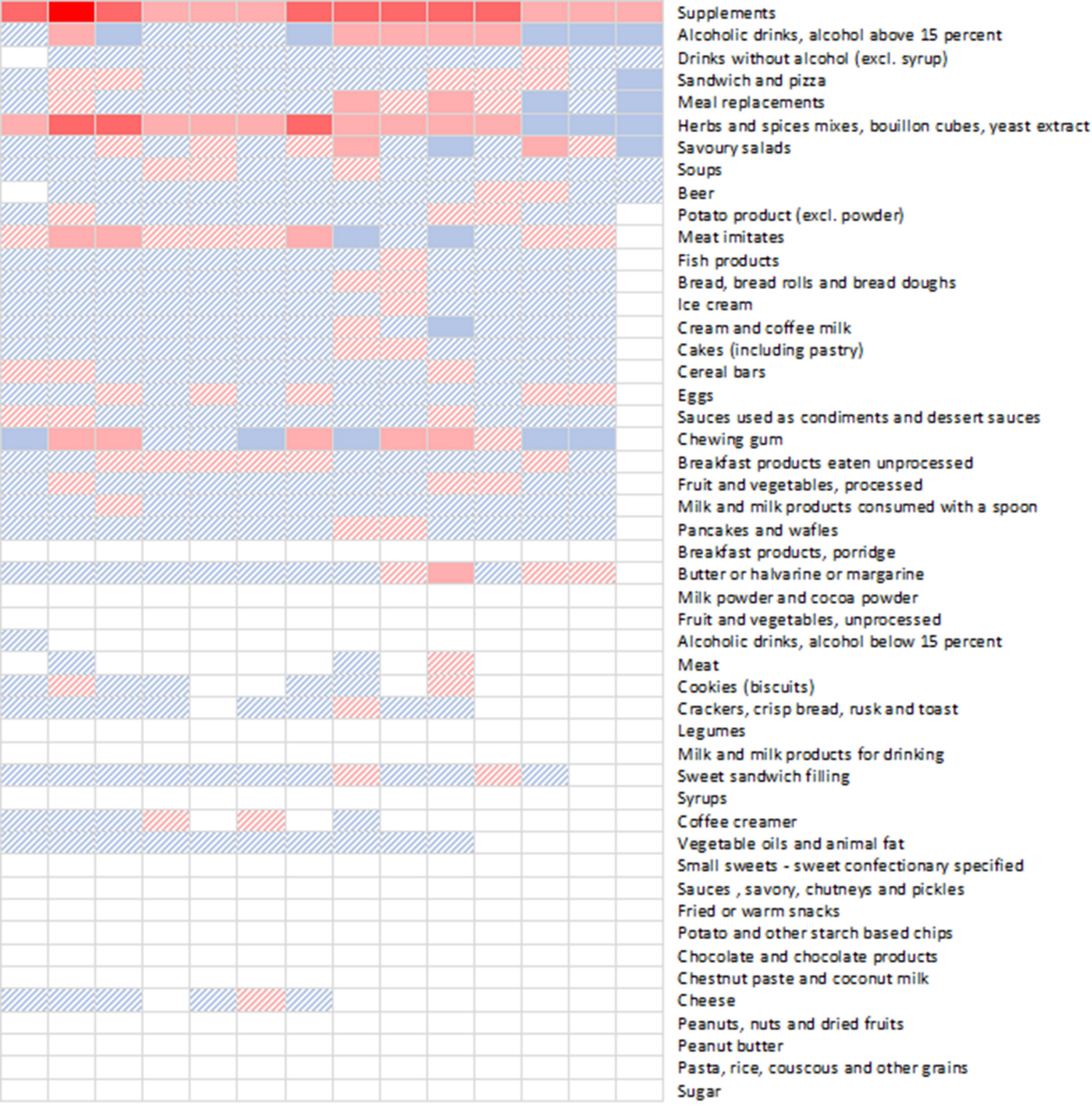

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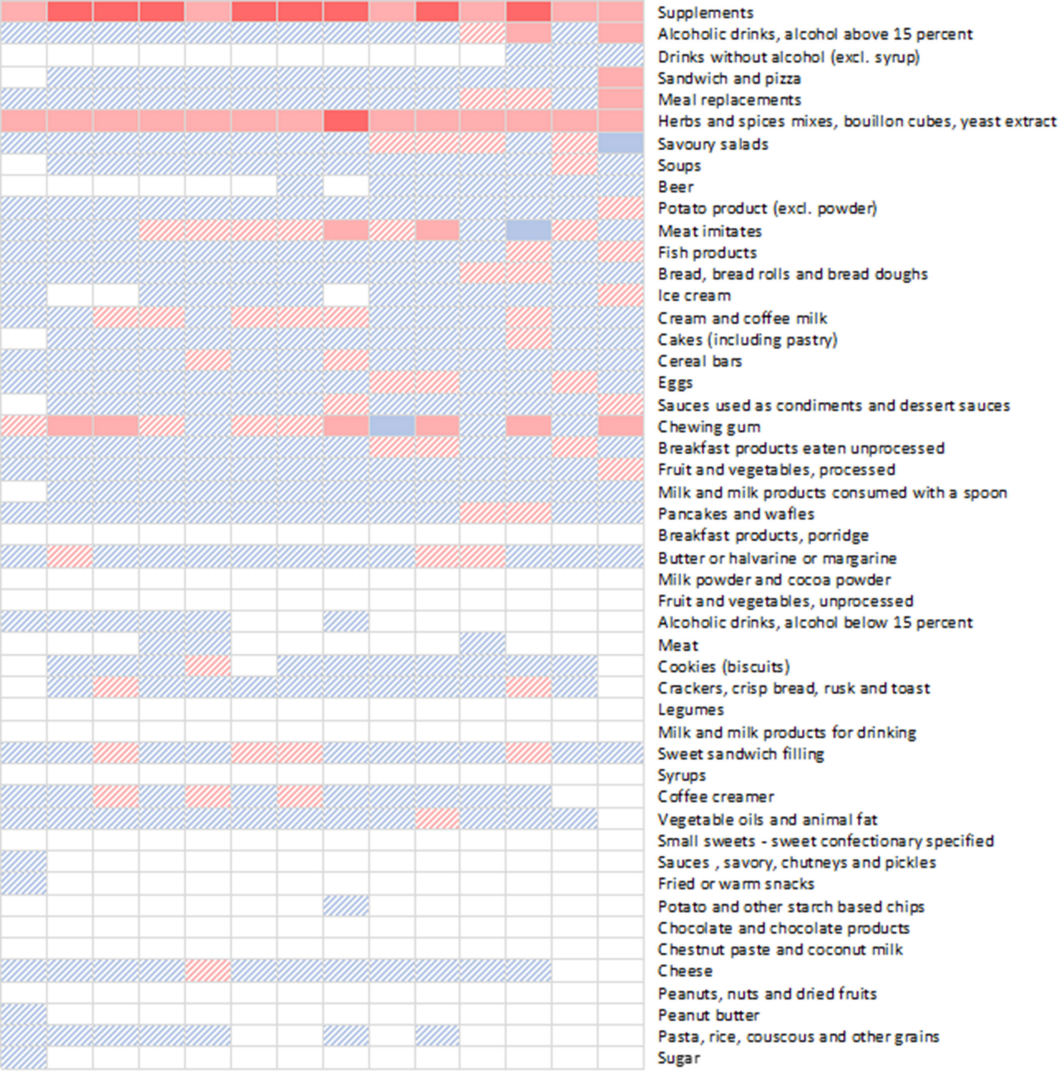

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