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Development of a risk-ranking framework to evaluate simultaneously biological and chemical hazards related to food safety: Application to emerging dietary practices in France

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Abstract

The objective of this study was to develop a structured and transparent framework to rank emerging dietary practices. The first challenge was to rank simultaneously biological and chemical hazards using the same criteria whatever the nature of the hazard. For a list of dietary practices selected based on the results of a survey, hazard identification and health effect characterization was carried out. Taking only the top five practices led to the identification of 41 triplets “emerging dietary practice – hazard – health effect”, which highlights the complexity of scoring risk in food safety. A wide variety of hazards, including microbes, parasites, mycotoxins, allergens and other chemical compounds were considered together with a range of health effects such as foodborne pathogen disease, anaphylaxis, cancer, immunosuppression, endocrine disturbance, etc. The second challenge was to develop a framework easy to populate and run. The risk-ranking framework included eight criteria: five to describe the severity, three to describe the likelihood. All of them were informed by literature data and food safety agencies’ reports, plus experts’ opinion. The PROMETHEE outranking MCDA technique, available in R package, was implemented. This risk-ranking framework applied to the results of our small-scale survey revealed that consuming nuts on a regular basis could be the emerging dietary habit presenting the highest-risk score, due to the aflatoxin B1 hazard and its associated health effect (liver cancer). This risk-ranking framework requires however to be applied furthermore in other contexts to evaluate its robustness and identify opportunities for improvement. Once consolidated, this framework will be highly relevant for food safety authorities and policy makers to move forward transparent and evidence-informed decisions.

1 -Introduction

The issue of dietary practices has become an increased subject of interest and concern for European citizens as well as for public authorities for several decades (Balanza et al., 2007; Recours & Hebel, 2007; Varela-Moreiras et al., 2010). In fact, this evolution of consumer's behaviour could lead to ambivalent situations such as those pointed out by the French survey INCA 2 (Gazan et al., 2016). The authors noticed that the so-called "health-conscious consumers" seeking for high nutritional value food and with food preferences including wholemeal flour or multigrain bread, fruits and vegetables, soup and also uncooked fish, were potentially more at risk for exposure to some chemical substances than the average French population (Gazan et al., 2016). Likewise, the consumption of raw fruits and vegetables could lead to an over exposure to microbiological risk (European Commission, 2002). In the same manner, eating raw fish - a type of consumption that has doubled within the last ten years in France (Anses, 2017) - could contribute to increase biological risk including risk due to zoonotic parasites. Furthermore, food safety risks could also result from the trendy and increasingly popular dietary practices such as daily intake of nuts and seeds or soy milk drinking (Eneroth, Wallin, Leander, Nilsson Sommar, & Akesson, 2017; Sataque Ono, Hirooka, Rossi, & Ono, 2011; Setchell, 2001).

Evaluating and ranking food safety risks associated with emerging dietary habits is required to move forward to comprehensive recommendations to consumers who may be inclined to neglect food safety in favour of healthy nutritional messages. Risk-ranking is a coherent, comprehensive, transparent and evidence-based process that permits to identify and prioritize risks (Anderson, Jaykus, Beaulieu, & Dennis, 2011; EFSA, 2015; FAO, 2017; National Academies of Sciences, 2010). It has been used for years in food safety monitoring programs and its interest has been highlighted in numerous reports (Van der Fels-Klerx et al., 2018). In the context of dietary practices, it is particularly important that the risk-ranking methodology combines all relevant biological and chemical hazards that might be related to these practices. Thus, it is necessary to deliver a realistic, comprehensive and accurate rank of the practices whatever the nature of the hazards. However, it should be mentioned that ranking risks related to both biological and chemical hazards is highly complex since these two kinds of hazards significantly differ in their characteristics which makes it hard to compare them using the same metrics (Langerholc, Lindqvist, & Sand, 2018). That is why, to date, only few developments aiming at comparing and ranking risks related to these two types of hazards associated with foods have been initiated by national and international agencies, like FDA and FAO (FAO, 2017; Newsome et al., 2009). One quantitative framework (FDA-iRISK) enabling users to assess, compare, and rank the risks posed by microbiological and chemical hazards in each of the food system stages (primary production; processing; distribution etc.) has been developed by the FDA in cooperation with the Institute of Food Technologists (IFT). FDA-iRISK uses input data related to exposure (consumption, prevalence, contamination levels), to dose-response relationships and to anticipated health effects of the hazard (Chen et al., 2013). Unfortunately, this whole set of data is not always available for all identified hazards and acquiring the lacking data may require considerable time, which prevents the implementation of rapid corrective actions. According to Van der Fels-Klerx et al. (2018), Multicriteria Decision Analysis (MCDA) appears as one of the most suitable methods for ranking simultaneously risks related to chemical and biological hazards, using both quantitative and qualitative data and criteria chosen by the decision maker. MCDA has been applied to public health (Baltussen & Niessen, 2006; Linkov et al., 2006); in food safety, a few MCDA frameworks have been suggested to include the burden of diseases in the decision making process beside cost of intervention, acceptability or sustainability (FAO, 2017; Fazil, Rajic, Sanchez, & McEwen, 2008; Ruzante, Grieger, Woodward, Lambertini, & Kowalcyk, 2017). However, in these frameworks, the details of the scoring method related to the biological and toxicological risk have not been provided.

The objective of the present study was to develop a structured and transparent framework to rank dietary practices considering simultaneously biological and chemical hazards. Moreover, the framework was design to i) be informed relatively rapidly (no need to generate data), ii) be reproducible and verifiable, iii) have a user-friendly interface, and finally iv) enable further improvement afterward. The MCDA PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) method was chosen; PROMETHEE is an outranking method particularly efficient when quantitative and qualitative criteria have to be taken into consideration (Wątróbski, Jankowski, Ziemba, Karczmarczyk, & Zioło, 2019). Moreover, PROMETHEE method has been used and advocated by FAO to classify risks related to food safety (FAO, 2017). The developed framework was tested using a set of data collected in France through a small-scale survey.

2-Materials and methods

2-1- Designing the risk-ranking framework for dietary practices

The framework developed here had the risk assessment definition (FAO/WHO Codex Alimentarius Commission, 2003) as reference, with severity and likelihood characterizing the risk. For each dietary practice, the list of hazards was established. For each hazard, the list of health effects was completed. These "dietary practice-hazard-health effect" constituted the triplets to be ranked. Next, for each triplet, eight criteria describing either the severity or the likelihood were scored according to a pre-established scoring rule (see columns in Table 1). The details of collected data to populate Table 1 is provided in the next section. Finally, different weights were given to each criterion (five criteria for severity and three for likelihood) with the aim to give the same importance to both severity and likelihood.

2-2-Generating the data to populate the framework

2-2-1-Identifying new dietary practices

An online survey was conducted using the SurveyMonkey tool: https://fr.surveymonkey.com/. SurveyMonkey has been operating in the EU for a number of years; the international headquarters are based in Dublin, Ireland. SurveyMonkey process respects the General Data Protection Regulation (GDPR) in force in Europe. It is reasonably cheap, the questionnaire is easy to set up and the survey is an on-line one. These four criteria led us to select this company. The survey was intended to the adult French population over 25 years old. It was published on French consumer's online forums such as "60 Millions de Consommateurs". Questions were closed-ended with single or multiple choice. The questions were oriented towards potentially risky practices based on INCA3 conclusions (Anses, 2017) and co-author's opinion. Moreover, two experts from public research institutes working in food safety domain were consulted:

Gaud Dervilly (Oniris, Nantes) for practices related to chemical contaminants, Jean-Pierre Cravedi (INRAE, Toulouse) for practices related to all other hazards. The two experts were consulted by individual interviews.

After one month on-line, the questionnaire was closed. Results were transferred to Excel for a first analysis. It was considered that a practice was "emerging" when a person responding to the survey said that he/she had currently adopted this practice AND he/she did not (or only sporadically) have this practice 10 years ago. To develop the risk-ranking framework, the top five emerging practices were kept in the study.

2-2-2-Identifying the hazards and the health effects related to each practice

a-Identifying the hazards

The list of hazards to be considered for each practice was established using the Food and Feed Safety Alerts – RASFF. The notifications associated with the food included in the practice (e.g. raw fish, nuts…) were checked for the period between March 2009 to March 2019. Next, the list of hazards was completed using the EFSA reports: "Trends and sources of zoonoses and zoonotic agents in foodstuffs, animals and feeding stuffs" during the 2000 to 2017 period and "The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2017" (EFSA and ECDC, 2018). Finally, besides all the co-authors, the expert Jean-Pierre Cravedi, specialist in food toxicology was interviewed to refine the list.

b- Identifying the health effects

For each hazard, the health effects were established using the ANSES food-borne biohazard description factsheets (Anses, Updated 2019a) and "Les Etudes de l'Alimentation Totale – EAT" (Anses, Updated 2019b), for biological hazards and chemical hazards, respectively. The established list was completed by literature search and fine-tuned by food toxicologists and microbiologists (all co-authors plus Jean-Pierre Cravedi cited above).

2-2-3-Scoring the criteria

For the severity, five criteria were informed: Fatality Rate, Proportion of hospitalized people among diagnosed people, Duration of symptoms, Probability of sequelae, Target population

(Table 1). For each triplet “practice-hazard-health effect”, the criteria were scored as detailed below.

For mortality and hospitalization statistics related to biological hazards, the report « Morbidité et mortalité dues aux maladies infectieuses d’origine alimentaires en France” (Vaillant, de Valk, & Baron, 2003) was considered. For mortality statistics related to carcinogenic chemicals, the report « Survie des personnes atteintes de cancer en France métropolitaine 1989-2013 » (Cowppli-Bony et al., 2016) was the primary source of information. The percentage of mortality obtained from the previous reports was scored in a semi-quantitative scale to characterize the **Fatality Rate** as “low” for less than 5%, “medium” for scores between 5 and 50%, and “high” when the score was higher than 50%. Likewise, the **Proportion of hospitalized people among diagnosed people** was scored as “low” when less than 5%, “medium” for the 5-50 % range and “high” for values higher than 50%.

For the duration of symptoms related to biological hazards, the Anses food-borne biohazard description factsheets (Anses, Updated 2019a) were analysed in addition to ICMSF (2018). When this information was missing, the assigned score was based on a consensus among co-authors. The **Duration of symptoms** criterion was scored “Low” when duration was estimated to be few days by co-authors or short according to ICMSF classification (ICMSF, 2018), “medium” when it was few weeks or moderate, “high” when it was more than several weeks or long.

The presence or absence of sequelae was assessed based on ICMSF (2018) or by co-author consensus when the information was missing. The **Probability of sequelae** score was “low” when associated to no sequelae, “medium” in the case of possible sequelae, “high” when sequelae are likely to occur.

The concerned population or “target population” by the health effect was assessed using ICMSF (2018) or by consensus among co-authors when the information was missing; the **Target population** score was “yes” when the general population was concerned, “no” when only a specific population was concerned.

For the likelihood, three criteria were informed: Strength of the link between habit/food and the hazard, Number of people adopting this habit, Percentage of people who “always” or “often” follow this habit (Table 1).

Data from the RASFF Portal were analysed to highlight the number of notifications related to biological and chemical hazards. The number of outbreaks related to biological hazards was defined according to the EFSA reports “Trends and sources of zoonoses and zoonotic agents in foodstuffs, animals and feeding stuffs” (from 2000 to 2017). These two quantitative values were used to establish the **Strength of the link between habit/food and hazard** criteria. Firstly, the RASFF notifications values were converted to low, medium, high scores respectively when there were less than 100 notifications, between 100 and 1000 notifications, and more than 1000 notifications. The EFSA outbreak values were converted to low, medium, high scores when there were less than 5 outbreaks, between 5 and 50 outbreaks, and more than 50 outbreaks, respectively. Secondly, the strength of the link between habit/food and hazard criterion was established using the following rules: when the notification AND outbreak were both scored low, the Strength of the link between habit/food and hazard criterion was characterized as “low”; when notification was scored high and the outbreak medium or high, and vice versa, then the Strength of the link between habit/food and hazard criterion was characterized “high”; in the other cases, the Strength of the link between habit/food and hazard criterion was characterized as “medium”.

The **Number of people having this habit** and the **Percentage of people “always” or “often” having this habit** resulted from the survey analysis (Table 1). These numbers were reported as they were, without any particular scoring system.

2-2-4-The multicriteria analysis

Table 1 was analysed with the MCDA PROMETHEE method (Brans, Vincke, & Mareschal, 1986). PROMETHEE belongs to the outranking methods first introduced by Roy (1968). The analysis was done with the PROMETHEE package in R (version 3.5.1) associated with the R Studio interface (version 1.1.463).

In PROMETHEE, the overall ranking of the alternatives (hereby “practice-hazard-health effect” triplets) is generated using “positive flows”, “negative flows” and “net flows”. The positive flow,

ϕ^+, indicates the degree to which the alternative is dominating all others, the negative flow, ϕ^-, indicates the degree to which the alternative is being dominated by all the others (Brans & Vincke, 1985). The net flow, $\phi = \phi^+ - \phi^-$, is used to rank overall the alternatives: the preferred alternative will get the highest net flow. An ideal alternative would have a positive flow equal to 1, a negative flow equal to 0 and consequently a net flow equal to 1.

The preference chosen was V-shape for all criteria and the indifference was set to zero. The weights were 1, 0.75, 0.75, 0.25, 0.25 for Fatality Rate, Proportion of hospitalized people among diagnosed people, Duration of symptoms, Probability of sequelae, Target population, respectively. This led to a total of 3 for the severity. The weights were 1, 1, 1 for Strength of the link between habit/food and the hazard, Number of people having this habit, Percentage of people “always” or “often” having this habit, respectively. This led to a total of 3 for the likelihood, meaning that the same importance was given to severity and likelihood.

When the score of a criterion was given as a range - for instance the Medium to High score for Hospitalization related to the triplet “Raw Fish – Cadmium - Renal impairment” - the lowest value of the interval was used to establish the rank, for instance Medium in the previously mentioned case.

3-Results and Discussion

3-1- Framework to rank dietary practices regarding their potential biological and chemical risks

The key conceptual features of the risk-ranking framework developed in the present study are reported in Figures 1 and 2. Figure 1 describes the general approach used to rank the dietary habits based on their potential biological and chemical risks. The first step aims at identifying dietary habits of interest. In our case, the considered dietary habits were the emerging ones selected based on the results of a survey. When such an initiative is undertaken by decision makers or food safety agencies, they usually use available data or build their own survey when the required data are lacking. The second step of the framework development aims identifying the most significant hazards associated with each practice: this hazard identification step can be achieved using different sources of information including data provided by Rapid Alert Systems available in a specific country or area, experts knowledge and additional published scientific information. The last step of the framework development consists in identifying the adverse health effects for each hazard. There may be more than one health effect for a given hazard. This health effect identification can be carried out using scientific articles, agencies reports and experts' opinions. Once these three steps are achieved, a list of "Practice-Hazard-Health effect" triplets is obtained. The next step consists in ranking these triplets, based on an outranking MCDA method as detailed in Figure 2. Once each triplet had a score, i.e. a Phi value, dietary habits could be scored: the dietary habit included in the triplet having the highest score was ranked at the highest risky dietary habit.

Figure 2 highlights the steps implemented in the outranking PROMETHEE MCDA method to assess and compare the risks related to the whole set of "Practice-Hazard-Health effect" triplets previously identified. To rank all the triplets regardless of the nature of the hazard (i.e. microbes, parasites, mycotoxins, allergens, other chemical compounds), it was decided to adopt a unique set of criteria. Since the risk in the food safety domain is defined as a function of the probability of an adverse health effect and the severity of that effect consequential to a hazard(s) in food (FAO/WHO Codex Alimentarius Commission, 2003), it was decided to keep severity and likelihood as supra criteria (Figure 2). Moreover, it was decided to ascribe the same weight for these two supra criteria, i.e. to consider that severity was as important as likelihood and vice versa. This latter decision is of course subjective, some decision makers might have considered that severity is more important than likelihood, others the opposite. The advantage of using an outranking method relies on the fact that all the inputs, i.e. data and weights, are transparently implemented. If the framework developed here is used for the same application (i.e. emerging dietary habit) but with different inputs or weights, the outputs (i.e. the risk ranking) is likely to be affected. For instance, decision makers can visualise the effect of attributing a set of weights on the outputs. In other words, they can visualize how the final risk ranking score is sensitive, or not, to the weights that they have given to the eight criteria.

According to experts in food safety risk assessment and reports on risk-ranking, there are two main measures for estimating the severity of a health effect. The first measure is mortality and the second one is morbidity. For the microbiological hazards, these measures are simultaneously quantified by calculating the Disability-Adjusted Life Year (DALY). Unfortunately this metric is not always applicable to chemicals since for many of them, the cause-effect relationship is hard to characterize (Van der Fels-Klerx et al. 2018). Accordingly, in the present study, we used the case fatality rate to score the mortality: this score was calculated by dividing the number of deaths due to a disease over the number of people diagnosed for this disease. As regards the morbidity, we used the following three criteria: (1) the proportion of hospitalized people due to a disease among the people that were diagnosed for the disease, (2) the duration of the symptoms and (3) the probability of sequelae. To better characterize the severity of the health effect, an additional criterion corresponding to the target population (the whole population or only a subset) was considered.

The likelihood, was assessed according to prevalence in food and consumption pattern (Figure2). Prevalence in food was established using the strength of the link between dietary habit and/or food and the hazard based on the number of notifications and the number of outbreaks reported by food safety agencies. The consumption pattern includes the number of people who adopt the dietary habit and how often they are practising it. Such an assessment of the likelihood can be rapidly obtained and is objective (based on data) but of course this assessment is not as accurate as one based on the quantification of the contamination doses in the food. It is important to keep in mind that collecting dose level information is resource- and labour-intensive, especially if a large variety of dietary habits and food is considered.

Interestingly, the framework we developed enables ranking dietary practices based on their potential risk regarding either the population level or the individual level. Indeed, by excluding the consumption criteria from the likelihood, the analysis can be interpreted per individual. An assessment at the population level makes sense for a decision maker, for instance a food safety authority, who wants to issue recommendations or make decisions at the national or international level. An assessment at the individual level enables to target, for instance in a communication plan, a specific dietary habit which can result in potential risks for some consumers. Indeed, consumers have the right to be informed as regards the food they consume. A Eurobarometer survey in 2019 showed that food safety is equally as important as food origin, cost and taste in their purchasing decision-making (EFSA, 2019). More generally, consumer's decisions are influenced, among other things, by health, economic, environmental, social, and ethical considerations.

To develop our risk-ranking framework, the PROMETHEE method (Brans et al., 1986), that has been used and advocated by FAO to classify risks related to food safety (FAO, 2017), was privileged. Besides, this approach is available as a package in R and is easy to implement. The general principle of outranking methods is to rank alternatives two by two based on criteria defined by the user and weights assigned to these criteria. Outranking methods enable to compare alternatives even if the criteria are semi-quantitative (e.g. low, medium, high) which is very convenient in the public health domain where the scoring system results at least partially from experts' opinion. Outranking methods have been widely employed in environmental problems when users are asked to select from a number of discrete alternatives (Herva & Roca, 2013). In the present study, the use of an outranking method was even more relevant as our objective was to establish a framework enabling to rank simultaneously biological and chemical hazards and that we had to face to a lack of data to quantify all criteria. The outranking PROMETHEE method has been acknowledged by Fazil et al. (2008) as an easy one to be implemented in the food safety domain. The PROMETHEE approach has allowed Ruzante et al. (2010) to prioritize six "pathogen bacteria – food matrix" pairs considering five criteria: public health, market impact, consumer perception and social sensitivity. In this latter study, the public health criteria were assessed according to the DALY metric, which is frequently used for estimating the burden of foodborne pathogens (Gkogka, Reij, Havelaar, Zwietering, & Gorris, 2011; Havelaar et al., 2004; Lake, Cressey, Campbell, & Oakley, 2010). Unfortunately this metric is rarely useable when chemical pollutants are considered (Van der Fels-Klerx et al. 2018).

While there have been recent initiatives of using MCDA to solve food supply chain problems (Duret et al., 2019; Sharma, Yadav, Mangla, & Patil, 2018), MCDA still remain less frequently used in the food industry sector than in other engineering sectors such as energy management (Mardani et al., 2017), building technology (Zavadskas, Antucheviciene, Vilutiene, & Adeli, 2018) or waste management (Soltani, Hewage, Reza, & Sadiq, 2015). However, recent initiatives performed at national scale (Merad, 2018) illustrate the interest of food safety agencies for aids in evidence-based decisions. Likewise, at the European scale, there is currently a demand for holistic approaches considering food safety in addition to health benefits, public savings, environmental impacts, etc. (EFSA, 2018). Accordingly, , food safety research has been introduced as part of a systemic food system approach to achieve food and nutrition security in the Food2030 agenda (European Commission, 2016). Thus, the use of MCDA applications in food safety is planned to increase in the next future.

3-2-Application to a case study

3-2-1-Results of the survey:

A total of 301 people aged of more than 25 years, mainly from the French department "Loire Atlantique" responded to the survey addressing the issue of new dietary practices. Results are gathered in Figure 3. The five most important emerging practices that were highlighted by the survey were the consumption of seeds, the use of silicone cookware, the consumption of nuts, the consumption of plant milks and finally the consumption of raw fish with percentages of 47.84%, 33.55%, 31.56%, 28.57% and 26.91% of the total respondents, respectively. The survey size was relatively small and geographically not representative of France. Therefore, the conclusions of this case-study cannot be considered as definitive for the French population even if the top-five emerging practices identified here were in-line with what generally reported for the French population (Anses, 2017). Nevertheless, the main objective of this survey, that was quick to set up and easy to organise through internet, was to collect an objective list of emerging dietary practices, or at least a more objective list than one obtained by consulting a limited number of experts or scientists. It enabled to test the risk-ranking framework on real data since the survey provided enough information to this purpose.

3-2-2- Hazards and health effects for each dietary habit

For each practice dietary habit, hazards were identified, and for each hazard, health effects were listed. For the first five most frequent dietary practices, a total of 41 Practice-Hazard-Health effect triplets with a large variety of hazards (microbes, parasites, mycotoxins, allergens, other chemical compounds) and health effects (foodborne pathogen disease, anaphylaxis, cancer, immunosuppression, endocrine disturbance…) was obtained. These first five dietary practices were used to validate the risk ranking framework. The associated data are presented in Table 1. For the most popular dietary habit within our 301-sample, i.e. the consumption of seeds, 10 hazards and 13 Practice-Hazard-Health effect triplets were identified. Regarding the emerging consumption of nuts and plant milks, 11 and 2 triplets were identified, respectively. The consumption of raw fish led to a list of 15 triplets. Finally, concerning the use of silicone cookware, no particular hazard was identified and consequently no health effect; this absence of hazard was discussed with a toxicologist expert who stated that when consumers buy silicone cookware stamped "French Standard" in dedicated cooking shops or established supermarkets, no proven record of any potential harm effect can be retrieved (Jean-Pierre Cravedi, unpublished data). This emerging dietary habit was therefore discarded from the risk-ranking analysis.

For most of the biological hazards identified such as *Salmonella spp.*, *Bacillus cereus*, norovirus, *Listeria monocytogenes, Clostridium perfringens*, *Vibrio parahaemolyticus*, it was considered that the health effect was "food poisoning" indiscriminately of the nature of the clinical signs since most of these agents are responsible for different syndromes including at the same time digestive signs, neurological signs, systemic signs etc. Moreover, since those hazards are acknowledged agents of specific food poisonings, associated mortality and morbidity data are well-informed whatever the related health effect. On the opposite, no mortality and morbidity data were available as regards chemical hazards. For this reason, the most significant health effects induced by a chronic digestive exposure were detailed (Ex: Liver cancer, reprotoxicity, anaphylaxis etc.) in order to estimate mortality and morbidity data based on these health effects.

After identifying the hazards and the health effects, the eight criteria were scored based on available data and experts' knowledge. It clearly appears in the red columns of Table 1 that almost all the triplets were characterized by high scores on certain criteria while medium or low scores were attributed to other criteria, which prompt us to use a multicriteria analysis to be able to classify the triplets.

3-2-3- Risk-ranking based upon the PROMETHEE algorithm

For the whole population, the final rank of the Practice-Hazard-Health effect triplets is presented in Figure 4. The triplets with the highest risk, considering only four dietary practices, were: Nuts-Aflatoxins B1-Liver Cancer, Nuts-Aflatoxins B1-Immunosuppression, Nuts-Propylene-Cancer, Nuts-Allergens-Anaphylaxis and Seeds-Aflatoxins B1-Liver Cancer with respective Phi(s) of 0.21, 0.14, 0.11, 0.11, and 0.10. The triplets Nuts-Aflatoxins B1-Liver Cancer and Seeds-Aflatoxins B1-Liver Cancer were characterized by equal scores on the Severity criteria. In contrast, on the likelihood criteria, with more than 3000 RASFF notifications as regards aflatoxin B1 contamination, nuts exceed largely seeds (105 notifications) in term of prevalence. Concerning the consumption, data included in the ranking analysis were the total number of consumers, whatever it was a new habit or not (meaning that the data used for scoring the likelihood are different from data used to identify new habit, see Figure 3). Nuts were declared to be consumed by 276 people 212 people have indicated a consumption of seeds. This difference is an additional reason explaining why nuts were scored above seeds in term of risk. The dietary habits having the lowest Phi scores were raw fish consumption, with Phi values of -0.10 for raw fish-*C. perfringens*-Food Poisoning and Raw fish-Norovirus-Food Poisoning. These low values mainly resulted from the “Low” scores ascribed to all the Severity criteria (Table 1).

Risk-ranking results per individual are reported in Figure 5. Interestingly, when Nuts-Aflatoxins B1-Liver cancer and Nuts-Aflatoxins-Immunosuppression were still at the top, Plant milk-Phytoestrogens-Endocrine disturbance was in the third position in this individual ranking. This result indicates that when an individual frequently consumes plant milk, he/she exposes him/herself to a high risk of endocrine disturbance. As it was observed for the entire population, applying the framework at the individual level led to the observation that consuming raw fish was the dietary habit at the lowest risk among the emerging habits studied here in details.

4. Conclusion

A structured and transparent framework to rank emerging dietary practices considering simultaneously biological and chemical hazards was successfully developed and applied to a case study. The framework was adapted to a large variety of hazards, i.e. microbes, parasites, mycotoxins, allergens, other chemical compounds and of health effects: foodborne pathogen disease, anaphylaxis, cancer, immunosuppression, endocrine disturbance, etc. The risk-ranking framework included in total eight criteria: five to describe the severity, three to describe the likelihood. It was decided to give the same weight to severity and likelihood. Results could be interpreted at both population and individual levels. In our data-limited case-study, consuming nuts on a regular basis was the dietary habit presenting the highest risk score, due to the hazard aflatoxin B1 and its associated health effect (liver cancer). Nuts are increasingly appreciated and consumed, as a result of their nutritional benefits (source of omega-3 fatty Acids) and their ready to eat character (no need of preparation or cooking). A recent study addressing the risk-benefit of consuming nuts showed that cardiovascular health benefits may outweigh the burden of carcinogenic effects attributed to aflatoxin B1 exposure (Eneroth et al., 2017). Nevertheless, ranking food safety risks associated with dietary practices remains essential for setting priorities in research, identifying vulnerable sub-populations and tailoring consumer communication plan. It may be as well as a preliminary step before carrying out a more comprehensive risk-benefit assessment of food (Nauta et al., 2018). The risk-ranking framework was developed using the PROMETHEE outranking MCDA technique, available as a package in R. The technique was transparent and easy to run. Developing transparent, structured and easy-to-use tools are highly useful to food safety authorities in charge of making decisions and disseminating them to a large audience. Nevertheless, the risk-ranking framework developed here is still in an infancy stage, it needs to be tested furthermore and in other contexts. Once consolidated, this framework will be highly relevant for policy makers willing to move forward transparent and evidence-informed decisions. Besides, this framework could go beyond consumers's choices as food safety requirements should also consider the product origins (imported or exported), the way the product has been handled in processing and trade, and even the choice of raw materials.

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Table

Table 1: Scores given to the eight criteria (five related to severity, three to likelihood) used in the framework to rank simultaneously chemical and biological risks due to dietary practices. When the criteria were built on indicators, the score given to these indicators are provided as well. Table 1A: Plant origin products, Severity criteria. Table 1B: Plant origin products, Likelihood criteria. Table 1C: Silicone cookware and raw fish, Severity criteria. Table 1D: Silicone cookware and raw fish, Likelihood criteria.

Figure captions

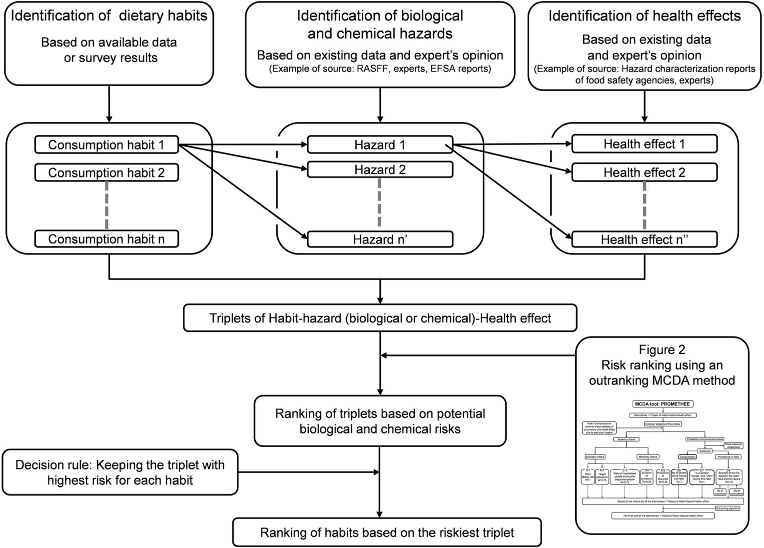
Figure 1: Framework to rank food safety risk. One consumption habit could lead to more than one hazard, itself potentially associated with more than one health effect. Once all the triplets of “habit-hazard-health effect” are established, they are ranked using the PROMETHEE MCDA method (detailed in Figure 2).

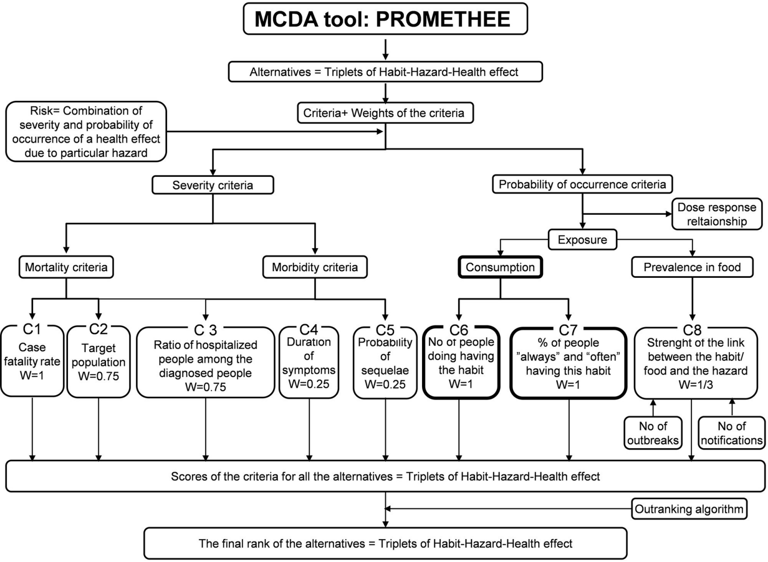
Figure 2: Details of the PROMETHEE method applied for ranking food safety risk. The ranking is based on criteria associated with severity or likelihood. All triplets “practice-hazard-health effect” (named here alternative) are scored using the same criteria whatever the nature of the hazard and the type of health effect.

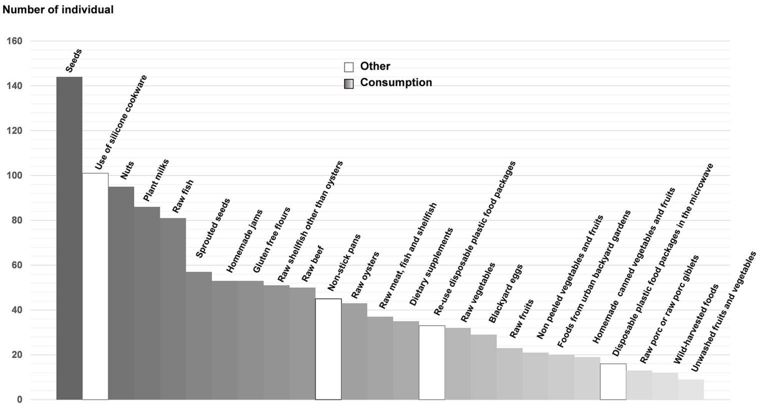
Figure 3: List of emerging dietary practices sorted by the number of people having adopted in the last 10 years, it in our survey (301 people in total)

Figure 4: Net flow Phi, ϕ, given to the 41 triplets “practice-hazard-health effect” scored with the PROMETHEE method. Analysis done at the population level.

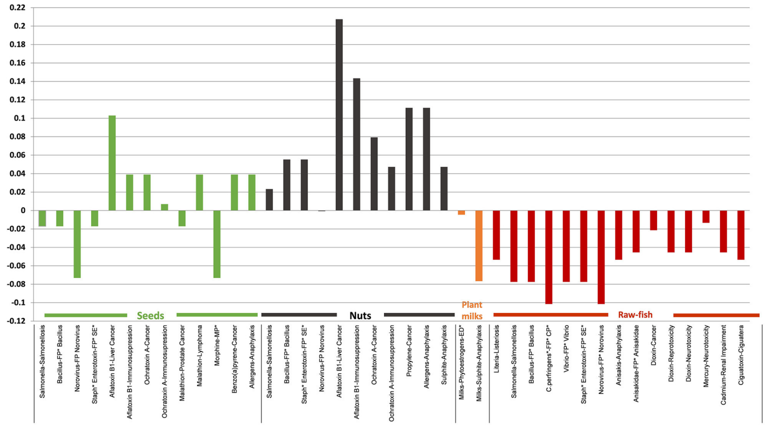
Figure 5: Net flow Phi, ϕ, given to the 41 triplets “practice-hazard-health effect” scored with the PROMETHEE method. Analysis done at the individual level.


Identification of dietary habits
Based on available data or survey results
Identification of biological and chemical hazards
Based on existing data and expert's opinion
(Example of source: RASFF, experts, EFSA reports)
Identification of health effects
Based on existing data and expert's opinion
(Example of source: Hazard characterization reports of food safety agencies, experts)
Consumption habit 1
Consumption habit 2
Consumption habit n
Hazard 1
Hazard 2
Hazard n'
Health effect 1
Health effect 2
Health effect n''
Triplets of Habit-hazard (biological or chemical)-Health effect
Figure 2
Risk ranking using an outranking MCDA method
MCDA tool: PROMETHEE
Ranking of triplets based on potential biological and chemical risks
Decision rule: Keeping the triplet with highest risk for each habit
Ranking of habits based on the riskiest triplet

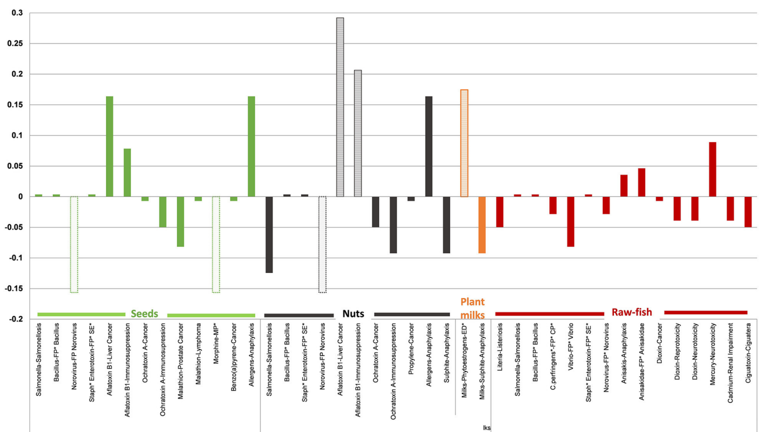

MCDA tool: PROMETHEE
Alternatives = Triplets of Habit-Hazard-Health effect
Risk= Combination of severity and probability of occurrence of a health effect due to particular hazard
Criteria+ Weights of the criteria
Severity criteria
Probability of occurrence criteria
Dose response reltaionship
Exposure
Mortality criteria
Morbidity criteria
Consumption
Prevalence in food
C1 Case fatality rate W=1
C2 Target population W=0.75
C 3 Ratio of hospitalized people among the diagnosed people W=0.75
C4 Duration of symptoms W=0.25
C5 Probability of sequelae W=0.25
C6 No of people doing having the habit W=1
C7 % of people "always" and "often" having this habit W=1
C8 Strenght of the link between the habit/ food and the hazard W=1/3
No of outbreaks
No of notifications
Scores of the criteria for all the alternatives = Triplets of Habit-Hazard-Health effect
Outranking algorithm
The final rank of the alternatives = Triplets of Habit-Hazard-Health effect



Number of individual
160
140
120
100
80
60
40
20
0
Other
Consumption
Seeds
Use of silicone cookware
Nuts
Plant milks
Raw fish
Sprouted seeds
Homemade jams
Gluten free flours
Raw shellfish other than oysters
Raw beef
Non-stick pans
Raw oysters
Raw meat, fish and shellfish
Dietary supplements
Re-use disposable plastic food packages
Raw vegetables
Blackyard eggs
Raw fruits
Non peeled vegetables and fruits
Foods from urban backyard gardens
Homemade canned vegetables and fruits
Disposable plastic food packages in the microwave
Raw porc or raw porc giblets
Wild-harvested foods
Unwashed fruits and vegetables



0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
Seeds
Nuts
Plant milks
Raw-fish
Salmonella-Salmonellosis
Bacillus-FP* Bacillus
Norovirus-FP Norovirus
Staph* Enterotoxin-FP* SE*
Aflatoxin B1-Liver Cancer
Aflatoxin B1-Immunosuppression
Ochratoxin A-Cancer
Ochratoxin A-Immunosuppression
Malathion-Prostate Cancer
Malathion-Lymphoma
Morphine-MP*
Benzo(a)pyrene-Cancer
Allergens-Anaphylaxis
Salmonella-Salmonellosis
Bacillus-FP* Bacillus
Staph* Enterotoxin-FP* SE*
Norovirus-FP Norovirus
Aflatoxin B1-Liver Cancer
Aflatoxin B1-Immunosuppression
Ochratoxin A-Cancer
Ochratoxin A-Immunosuppression
Propylene-Cancer
Allergens-Anaphylaxis
Sulphite-Anaphylaxis
Milks-Phytoestrogens-ED*
Milks-Sulphite-Anaphylaxis
Literia-Listeriosis
Salmonella-Salmonellosis
Bacillus-FP* Bacillus
C.perfringens*-FP* CP*
Vibrio-FP* Vibrio
Staph* Enterotoxin-FP* SE*
Norovirus-FP* Norovirus
Anisakis-Anaphylaxis
Anisakidae-FP* Anisakidae
Dioxin-Cancer
Dioxin-Reprotoxicity
Dioxin-Neurotoxicity
Mercury-Neurotoxicity
Cadmium-Renal Impairment
Ciguatoxin-Ciguatera


0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Seeds
Nuts
Plant milks
Raw-fish
Salmonella-Salmonellosis
Bacillus-FP* Bacillus
Norovirus-FP Norovirus
Staph* Enterotoxin-FP* SE*
Aflatoxin B1-Liver Cancer
Aflatoxin B1-Immunosuppression
Ochratoxin A-Cancer
Ochratoxin A-Immunosupression
Malathion-Prostate Cancer
Malathion-Lymphoma
Morphine-MP*
Benzo(a)pyrene-Cancer
Allergens-Anaphylaxis
Salmonella-Salmonellosis
Bacillus-FP* Bacillus
Staph* Enterotoxin-FP* SE*
Norovirus-FP Norovirus
Aflatoxin B1-Liver Cancer
Aflatoxin B1-Immunosuppression
Ochratoxin A-Cancer
Ochratoxin A-Immunosuppression
Propylene-Cancer
Allergens-Anaphylaxis
Sulphite-Anaphylaxis
Milks-Phytoestrogens-ED*
Milks-Sulphite-Anaphylaxis
lks
Literia-Listeriosis
Salmonella-Salmonellosis
Bacillus-FP* Bacillus
C.perfringens*-FP* CP*
Vibrio-FP* Vibrio
Staph* Enterotoxin-FP* SE*
Norovirus-FP* Norovirus
Anisakis-Anaphylaxis
Anisakidae-FP* Anisakidae
Dioxin-Cancer
Dioxin-Reprotoxicity
Dioxin-Neurotoxicity
Mercury-Neurotoxicity
Cadmium-Renal Impairment
Ciguatoxin-Ciguatera

Habits	Hazard	Adverse health effect	Weight of evidence	Severity																Likelihood							
				Case Fatality rate			Score Case Fatality rate	Ratio of hospitalized people among diagnosed people		Score Ratio of hospitalized people among diagnosed people	Duration of symptoms Anses factsheets	Duration of symptoms (Experts)	Score Duration of symptoms	Probability of sequelae Anses factsheets	Probability of sequelae (Experts)	Score Probability of sequelae	Target population Anses factsheets	Target population (Experts)	Score Target population	Strength of the link between the habit/ food and the hazard					Score Strenght of the link between the habit/ food and the hazard	Consumption	
				INVS AFSSA 2004	Other reports	Experts		INVS AFSSA 2004	Experts											No outbreaks (EFSA tends and sources of Zoonoses and zoonotic agents reports 2009-2017)	Score of No of outbreaks	No RASFF notifications (2009-2019)	Score of No of notifications	Experts opinion		Score No of people having this habit	Score % of people "always" or "often" having this habit
Seeds	*Salmonella spp.*	Salmonellosis	Proven	<1%	NA	NA	L	22%	NA	M	Few days	NA	L	NA	None	L	General population	NA	Yes	3	L	442	M	NA	M	212	46
	Bacillus cereus	Food poisoning		0%		NA	L	12%	NA	M	Few hours		L			L		NA		18	M	1	L		M	212	46
	Norovirus	Food poisoning		NA		L	L	NA	L	L	Few days		L			L				2	L	0			L	212	46
	Staphylococcal Enterotoxins	Food poisoning		0%		NA	L	18%	NA	M	Few hours		L			L				24	M	0			M	212	46
	Aflatoxin B1	Liver Cancer	Proven (Group 1)	NA	85%	NA	H	NA	>90%	H	NA	Few weeks to few years	M to H		Possible	M	NA	General population		NA	NA	105	M		M	212	46
		Immunosuppression	Proven		NA	L	L		M	M		Long	H			M						105	M		M	212	46
	Ochratoxin A	Cancer	Possibly (Group 2B)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H			M						7	L		L	212	46
		Immunosupression	Proven		NA	L to M	L to M		M to H	M to H		Long	H			M						7			L	212	46
	Malathion	Prostate Cancer	Probably (Group 2A)		6%	NA	L		>90%	H		Few weeks to few years	M to H		Sequelae	H		Specific popultaion	No			7			L	212	46
		Lymphoma			34%	NA	M		>90%	H		Few weeks to few years	M to H		Possible	M		General population	Yes			7			L	212	46
	Morphine	Morphine poisoning	Proven		NA NA	L	L		L	L		Short	L		None	L						9			L	212	46
	Benzo(a)pyrene	Cancer	Proven (Group 1)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H		Possible	M						3			L	212	46
	Allergens	Anaphylaxis	Proven		NA NA	M to H	M to H		H	H		Short	L		None	L		Specific popultaion	No			NA	NA	H	H	212	46
Silicone Cookware	No hazard was identified	No adverse health effect was identified																									
Nuts	*Salmonella spp.*	Salmonellosis	Proven	<1%	NA	NA	L	22%	NA	M	Few days	NA	L	NA	None	L	General population	NA	Yes	3	L	52	L	NA	L	276	69
	Bacillus cereus	Food poisoning	Proven	0%			L	12%		M	Few hours		L			L				18	M	1			M	276	69
	Staphylococcal Enterotoxins	Food poisoning	Proven	0%			L	18%		M	Few hours		L			L				24	M	0			M	276	69
	Norovirus	Food poisoning	Proven	ND	NA	L	L	NA	L	L	Few days		L			L				2	L	0			L	276	69
	Aflatoxin B1	Liver Cancer	Proven (Group 1)	NA	85%	NA	H		>90%	H	NA	Few weeks to few years	M to H		Possible	M	NA	General population		NA	NA	3225	H		H	276	69
		Immunosuppression	Proven		NA	L	L		M	M		Long	H			M						3225			H	276	69
	Ochratoxin A	Cancer	Possibly (Group 2B)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H			M		Specific population	No			29	L		L	276	69
		Immunosupression	Proven			L to M	L to M		M to H	M to H		Long	H			M						29			L	276	69
	Propylene oxid (ppo)	Cancer	Possibly (Group 2B)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H			M		General population	Yes			3			L	276	69
	Allergens	Anaphylaxis	Proven		NA	M to H	M to H		H	H		Short	L		None	L		Specific population	No			NA	NA	H	H	276	69
	Sulphite	Anaphylaxis				M to H	M to H		H	H		Short	L		None	L						12	L	NA	L	276	69
Plant milks	Phytoestrogenes	Endocrine disturbance	Proven	NA	NA	L to M	L to M	NA	M to H	M to H	Long	NA	H	NA	Sequelae	H	NA	Specific population	No	NA	NA	0	NA	H	H	125	40
	Sulphite	Anaphylaxis				M to H	M to H	NA	H	H	NA	Short	L		None	L						6	L	y	L	125	40
Raw fish	*Listeria monocytogenes*	listeriosis	Proven	25%	NA	NA	M	100%	NA	H	Many days	NA	M	Possible	NA	M	NA	Specific population	No	NA	NA	92	L	NA	L	178	22
	Salmonella spp.	Salmonellosis		<1%			L	22%		M	Few days		L	NA	None	L	General population	NA	Yes	10	M	27	L	NA	M	178	22
	Bacillus cereus	Food poisoning		0%			L	12%		M	Few hours	NA	L			L				42	M	0			M	178	22
	Clostridium perfringens	Food poisoning		<0 .1%			L	1 .2%		L	Few days		L			L				10	M	0			M	178	22
	Vibrio parahaemolyticus	Food poisoning		7%			L	21%		M	Few days		L			L				2	L	0			L	178	22
	Staphylococcal Enterotoxins	Food poisoning		0%			L	18%		M	Few hours		L			L				62	H	3			M	178	22
	Norovirus	Food poisoning		ND		L	L	NA	L	L	Few days		L			L				9	M	1			M	178	22
	Anisakidae	Anaphylaxis		NA		M to H	M to H	NA	H	H	One day		L			L	Specific popultation		No	NA		350	M		M	178	22
		Food poisoning		0%		NA	L	75%	NA	H	Few days to few weeks		L to M		Possible	M	General population		Yes			350	M		M	178	22
	Dioxin and dioxin like PCBs	Cancer		NA	34-67%	NA	M to H	NA	>90%	H	NA	Few weeks to few years	M to H		Possible	M	NA	General population	Yes		NA	22	L		L	178	22
		Reprotoxicity		NA	NA	L	L		M	M		Long	H		Sequelae	H									L	178	22
		Neurotoxicity					L			M			H			H									L	178	22
	Mercury	Neurotoxicity					L			M			H			H						898	M		M	178	22
	Cadmium	Renal empairment				L to M	L to M		M to H	M to H			H			H						56	L		L	178	22
	Ciguatoxins	Ciguatera poisoning		NA	1%	NA	L		M	M	Few months to few years	NA	H		Possible	M				62	H	8	L		L	178	22

L: Low, M: Medium, H: High

Habits	Hazard	Adverse health effect	Weight of evidence	Severity															
				Case Fatality rate			Score Case Fatality rate	Ratio of hospitalized people among diagnosed people		Score Ratio of hospitalized people among diagnosed people	Duration of symptoms Anses factsheets	Duration of symptoms (Experts)	Score Duration of symptoms	Probability of sequelae Anses factsheets	Probability of sequelae (Experts)	Score Probability of sequelae	Target population Anses factsheets	Target population (Experts)	Score Target population
				INVS AFSSA 2004	Other reports	Experts		INVS AFSSA 2004	Experts										
Seeds	*Salmonella spp.*	Salmonellosis	Proven	<1%	NA	NA	L	22%	NA	M	Few days	NA	L	NA	None	L	General population	NA	Yes
	Bacillus cereus	Food poisoning		0%		NA	L	12%	NA	M	Few hours		L			L		NA	
	Norovirus	Food poisoning		NA		L	L	NA	L	L	Few days		L			L			
	Staphylococcal Enterotoxins	Food poisoning		0%		NA	L	18%	NA	M	Few hours		L			L			
	Aflatoxin B1	Liver Cancer	Proven (Group 1)	NA	85%	NA	H	NA	>90%	H	NA	Few weeks to few years	M to H		Possible	M	NA	General population	
		Immunosuppression	Proven		NA	L	L		M	M		Long	H			M			
	Ochratoxin A	Cancer	Possibly (Group 2B)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H			M			
		Immunosupression	Proven		NA	L to M	L to M		M to H	M to H		Long	H			M			
	Malathion	Prostate Cancer	Probably (Group 2A)		6%	NA	L		>90%	H		Few weeks to few years	M to H		Sequelae	H		Specific populaion	No
		Lymphoma			34%	NA	M		>90%	H		Few weeks to few years	M to H		Possible	M		General population	Yes
	Morphine	Morphine poisoning	Proven		NA NA	L	L		L	L		Short	L		None	L			
	Benzo(a)pyrene	Cancer	Proven (Group 1)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H		Possible	M			
	Allergens	Anaphylaxis	Proven		NA NA	M to H	M to H		H	H		Short	L		None	L		Specific populaion	No
Nuts	*Salmonella spp.*	Salmonellosis	Proven	<1%	NA	NA	L	22%	NA	M	Few days	NA	L	NA	None	L	General population	NA	Yes
	Bacillus cereus	Food poisoning	Proven	0%			L	12%		M	Few hours		L			L			
	Staphylococcal Enterotoxins	Food poisoning	Proven	0%			L	18%		M	Few hours		L			L			
	Norovirus	Food poisoning	Proven	ND	NA	L	L	NA	L	L	Few days		L			L			
	Aflatoxin B1	Liver Cancer	Proven (Group 1)	NA	85%	NA	H		>90%	H	NA	Few weeks to few years	M to H		Possible	M	NA	General population	
		Immunosuppression	Proven		NA	L	L		M	M		Long	H			M			
	Ochratoxin A	Cancer	Possibly (Group 2B)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H			M		Specific population	No
		Immunosupression	Proven			L to M	L to M		M to H	M to H		Long	H			M			
	Propylene oxid (ppo)	Cancer	Possibly (Group 2B)		34-67%	NA	M to H		>90%	H		Few weeks to few years	M to H			M		General population	Yes
	Allergens	Anaphylaxis	Proven		NA	M to H	M to H		H	H		Short	L		None	L		Specific population	No
	Sulphite	Anaphylaxis				M to H	M to H		H	H		Short	L		None	L			
Plant milks	Phytoestrogenes	Endocrine disturbance	Proven	NA	NA	L to M	L to M	NA	M to H	M to H	Long	NA	H	NA	Sequelae	H	NA	Specific population	No
	Sulphite	Anaphylaxis				M to H	M to H	NA	H	H	NA	Short	L		None	L			

L: Low, M: Medium, H: High

Habits	Hazard	Adverse health effect	Weight of evidence	Likelihood							
				Strength of the link between the habit/ food and the hazard					Score Strenght of the link between the habit/ food and the hazard	Consumption	
				No outbreaks (EFSA tends and sources of Zoonoses and zoonotic agents reports 2009-2017)	Score of No of outbreaks	No RASFF notifications (2009-2019)	Score of No of notifications	Experts opinion		Score No of people having this habit	Score % of people "always" or "often" having this habit
Seeds	*Salmonella spp.*	Salmonellosis	Proven	3	L	442	M	NA	M	212	46
	Bacillus cereus	Food poisoning		18	M	1	L		M	212	46
	Norovirus	Food poisoning		2	L	0			L	212	46
	Staphylococcal Enterotoxins	Food poisoning		24	M	0			M	212	46
	Aflatoxin B1	Liver Cancer	Proven (Group 1)	NA	NA	105	M		M	212	46
		Immunosuppression	Proven			105	M		M	212	46
	Ochratoxin A	Cancer	Possibly (Group 2B)			7	L		L	212	46
		Immunosupression	Proven			7			L	212	46
	Malathion	Prostate Cancer	Probably (Group 2A)			7			L	212	46
		Lymphoma				7			L	212	46
	Morphine	Morphine poisoning	Proven			9			L	212	46
	Benzo(a)pyrene	Cancer	Proven (Group 1)			3			L	212	46
	Allergens	Anaphylaxis	Proven			NA	NA	H	H	212	46
Nuts	*Salmonella spp.*	Salmonellosis	Proven	3	L	52	L	NA	L	276	69
	Bacillus cereus	Food poisoning	Proven	18	M	1			M	276	69
	Staphylococcal Enterotoxins	Food poisoning	Proven	24	M	0			M	276	69
	Norovirus	Food poisoning	Proven	2	L	0			L	276	69
	Aflatoxin B1	Liver Cancer	Proven (Group 1)	NA	NA	3225	H		H	276	69
		Immunosuppression	Proven			3225			H	276	69
	Ochratoxin A	Cancer	Possibly (Group 2B)			29	L		L	276	69
		Immunosupression	Proven			29			L	276	69
	Propylene oxid (ppo)	Cancer	Possibly (Group 2B)			3			L	276	69
	Allergens	Anaphylaxis	Proven			NA	NA	H	H	276	69
	Sulphite	Anaphylaxis				12	L	NA	L	276	69
Plant milks	Phytoestrogenes	Endocrine disturbance	Proven	NA	NA	0	NA	H	H	125	40
	Sulphite	Anaphylaxis				6	L	y	L	125	40

L: Low, M: Medium, H: High

Habits	Hazard	Adverse health effect	Weight of evidence	Severity															
				Case Fatality rate			Score Case Fatality rate	Ratio of hospitalized people among diagnosed people		Score Ratio of hospitalized people among diagnosed people	Duration of symptoms Anses factsheets	Duration of symptoms (Experts)	Score Duration of symptoms	Probability of sequelae Anses factsheets	Probability of sequelae (Experts)	Score Probability of sequelae	Target population Anses factsheets	Target population (Experts)	Score Target population
				INVS AFSSA 2004	Other reports	Experts		INVS AFSSA 2004	Experts										
Silicone Cookware	No hazard was identified	No adverse health effect was identified																	
Raw fish	*Listeria monocytogenes*	listeriosis	Proven	25%	NA	NA	M	100%	NA	H	Many days	NA	M	Possible	NA	M	NA	Specific population	No
	Salmonella spp.	Salmonellosis		<1%			L	22%		M	Few days		L	NA	None	L	General population	NA	Yes
	Bacillus cereus	Food poisoning		0%			L	12%		M	Few hours	NA	L			L			
	Clostridium perfringens	Food poisoning		<0 .1%			L	1 .2%		L	Few days		L			L			
	Vibrio parahaemolyticus	Food poisoning		7%			L	21%		M	Few days		L			L			
	Staphylococcal Enterotoxins	Food poisoning		0%			L	18%		M	Few hours		L			L			
	Norovirus	Food poisoning		ND		L	L	NA	L	L	Few days		L			L			
	Anisakidae	Anaphylaxis		NA		M to H	M to H	NA	H	H	One day		L			L	Specific population		No
		Food poisoning		0%		NA	L	75%	NA	H	Few days to few weeks		L to M		Possible	M	General population		Yes
	Dioxin and dioxin like PCBs	Cancer		NA	34-67%	NA	M to H	NA	>90%	H	NA	Few weeks to few years	M to H		Possible	M	NA	General population	Yes
		Reprotoxicity		NA	NA	L	L		M	M		Long	H		Sequelae	H			
		Neurotoxicity					L			M			H			H			
	Mercury	Neurotoxicity					L			M			H			H			
	Cadmium	Renal empairment				L to M	L to M		M to H	M to H			H			H			
	Ciguatoxins	Ciguatera poisoning		NA	1%	NA	L		M	M	Few months to few years	NA	H		Possible	M			

L: Low, M: Medium, H: High

Habits	Hazard	Adverse health effect	Weight of evidence	Likelihood							
				Strength of the link between the habit/ food and the hazard					Score Strenght of the link between the habit/ food and the hazard	Consumption	
				No outbreaks (EFSA tends and sources of Zoonoses and zoonotic agents reports 2009-2017)	Score of No of outbreaks	No RASFF notifications (2009-2019)	Score of No of notifications	Experts opinion		Score No of people having this habit	Score % of people "always" or "often" having this habit
Silicone Cookware	No hazard was identified	No adverse health effect was identified									
Raw fish	*Listeria monocytogenes*	listeriosis	Proven	NA	NA	92	L	NA	**L**	**178**	**22**
	Salmonella spp.	Salmonellosis		10	M	27	L	NA	**M**	**178**	**22**
	Bacillus cereus	Food poisoning		42	M	0			**M**	**178**	**22**
	Clostridium perfringens	Food poisoning		10	M	0			**M**	**178**	**22**
	Vibrio parahaemolyticus	Food poisoning		2	L	0			**L**	**178**	**22**
	Staphylococcal Enterotoxins	Food poisoning		62	H	3			**M**	**178**	**22**
	Norovirus	Food poisoning		9	M	1			**M**	**178**	**22**
	Anisakidae	Anaphylaxis		NA		350	M		**M**	**178**	**22**
		Food poisoning				350	M		**M**	**178**	**22**
	Dioxin and dioxin like PCBs	Cancer			NA	22	L		**L**	**178**	**22**
		Reprotoxicity							**L**	**178**	**22**
		Neurotoxicity							**L**	**178**	**22**
	Mercury	Neurotoxicity				898	M		**M**	**178**	**22**
	Cadmium	Renal empairment				56	L		**L**	**178**	**22**
	Ciguatoxins	Ciguatera poisoning		62	H	8	L		**L**	**178**	**22**

L: Low, M: Medium, H: High