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Border Rejections Reported in the Rapid Alert System for Food and Feed (RASFF) in 2008–2023: Identification of Hazards and Overview of Their Potential Health Implications

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Abstract: An important element of sustainability is food security, related to ensuring access to suitable food. Despite having an intensive agricultural economy and a developed food industry, European Union (EU) countries import some products. Within the Rapid Alert System for Food and Feed (RASFF), so-called border rejections are reported, which accounted for 38.7% of all notifications submitted in 2008–2023. The purpose of this study was to analyse border rejections reported in the RASFF in 2008–2023, considering hazards, hazard categories, product categories, notifying country, and country of origin. The data were pre-processed in Microsoft Excel and then subjected to two-way joining cluster analysis in Statistica 13.3. Taking into account the quantity of imports and the hazards, the greatest attention should be paid to fruits and vegetables from Turkey (presence of ochratoxin A, pesticides, and sulphites), nuts from Turkey (aflatoxins), poultry and spices from Brazil (*Salmonella* spp.), fish from China and Morocco (poor temperature control), and feed and fruits and vegetables from Ukraine (moulds). Through border rejections, the common European market is protected from hazards in food from outside the EU, which contributes to sustainability. However, ensuring safety in this regard requires close cooperation between border posts of all member countries.

Keywords: food safety; RASFF; border rejections; import; European Union

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1. Introduction

Within the European Green Deal, referring to agriculture, there is mention of a healthy food system for people and the planet. In turn, under the Common Agricultural Policy (CAP), not only are financial flows realised, but the internal food market is also protected. The European Union (EU)'s objectives in the Green Deal include leading a global transition towards competitive sustainability from farm to fork, as well as ensuring food security in view of geopolitical uncertainties, climate change, and biodiversity loss [1]. One aspect of food security is assuring that there is enough food, and the EU has a significant food trade surplus [2]. Despite this surplus, in 2022, the EU was the world's second-largest importer of food and beverages by value after the United States and ahead of China, the United Kingdom, and Japan, and this import is increasing each year [3]. Imported food products include those that can be obtained more cheaply in the interest of the EU economy or those that are not procurable under European climatic conditions (e.g., certain fruits, nuts, herbs, and spices).

The Rapid Alert System for Food and Feed (RASFF) plays a very important control role in the safety of imported food, as it carries out so-called border rejections. This system was already established in 1979, but it is now based on Regulation (EC) 178/2002, also known as the General Food Law. The members of this system are mainly member countries of the EU. If a risk to public health arising from the food chain arises, the RASFF ensures that information is exchanged between its members to support swift reaction by food safety authorities. Since 2021, the RASFF has been part of the Alert and Cooperation Network (ACN), which currently also consists of the Administrative Assistance and Cooperation Network (AAC), the EU Agri-Food Fraud Network (FFN), and the Plant Health Network (PHN) [4].

Within the RASFF, the following types of notifications are reported: alerts, information, news, and border rejections, which began to be recorded in the system in 2008. Although border rejections only started to appear in the RASFF as a separate type of notification in 2008, non-European exporters had already previously experienced border control and rejection of their products [5–9]. Border rejections include food and feed consignments that have been tested and rejected at the external border of the EU (and more broadly the European Economic Area (EEA) and Switzerland) if a health risk has been found. They are sent to all EEA border posts to reinforce controls and ensure that the rejected products do not enter the common EU market through another border post [4].

Border rejections occur due to risks found in batches, containers, food cargo, food contact material, or feed. These can include direct or indirect risks to human health in connection with food, food contact material, or feed, or a serious risk to animal health or to the environment in connection with feed, including feed for animals not kept for food production [10]. Shipments from third-party countries are rejected at the EEA border if they exceed the Maximum Residue Level (MRL) [11] or if prohibited substances are detected in food products. Figure 1 shows the border rejections reported in the RASFF by product categories between 2008 and 2023. These categories are presented in descending order by the number of notifications.

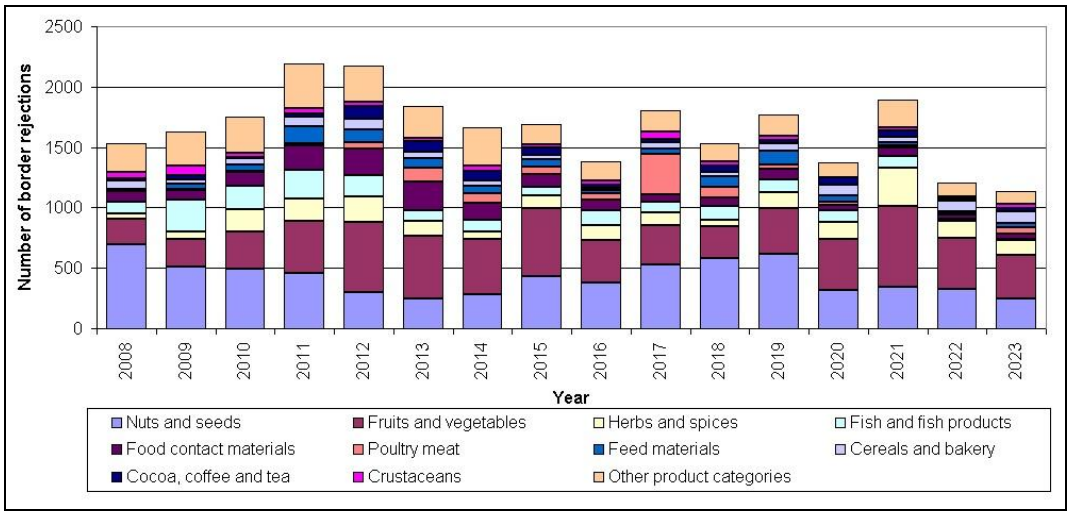

Figure 1. Border rejections reported in the RASFF in 2008–2023. Explanation of abbreviations used: Cereals and bakery—Cereals and bakery products, Cocoa, coffee and tea—Cocoa and cocoa preparations, coffee and tea, Crustaceans—Crustaceans and products thereof, Nuts and seeds—Nuts, nut products and seeds, Poultry meat—Poultry meat and poultry meat products.

The most frequently reported product categories were nuts, nut products and seeds, fruits and vegetables, herbs and spices, fish and fish products, and food contact materials. The number of border rejections reported in the RASFF was quite varied, fluctuating

predominantly in the range of 1500–2000 per year between 2008 and 2021, but it dropped to around 1000 notifications between 2022 and 2023. It is worth noting, however, that this decline may have been due to two factors: the moving of some data from the RASFF to other networks (ACN, FFN, and PHN mentioned above), and the United Kingdom ceasing to report notifications. Indeed, this country stopped being a member of the EU after Brexit in 2020 and has been excluded from the RASFF since 2021.

The issue of border rejections (resulting from food import) reported under the RASFF is raised in scientific works, but most often, the problem is only mentioned without providing a cross-sectional or multidimensional analysis. Meanwhile, it is an important issue due to the significant share of border rejections in the total number of notifications in the RASFF, as well as the health risks and health safety consequences that may occur as a result of consuming contaminated food. There are a few studies in the literature on this topic; however, they are not exhaustive, as they only address select topics [12–14].

Therefore, the purpose of this study was to analyse border rejections reported in the RASFF in 2008–2023, taking into account hazards, hazard categories, product categories, notifying country, and country of origin. The following research questions were posed in order to meet this purpose: (i) Which hazards (and under which hazards categories) were reported as border rejections in the RASFF? (ii) in which product categories were the notified hazards found? (iii) Which EU countries reported the notified products and from which countries did they originate? (iv) What was the relationship between imports and reported hazards? (v) What are the links between keywords such as import, food, and European Union and other words, as indicated by the authors of research papers? (vi) What are the potential health implications associated with exposure to the identified hazards?

2. Materials and Methods

Currently, on the European Commission's platform, only RASFF data from 2020 are provided, so there are no historical data [4]. Therefore, the data for the study were exported from two RASFF databases: the restored (archived) one, containing data for 2008–2021 [15], and the one currently available, with data for 2022–2023 [16]. These data were then merged. Thus, the data were extracted for the entire period, i.e., 2008–2023 (16 years), in which border rejections were reported in the RASFF. This included a total of 26,565 notifications, representing 38.7% (more than 26,500 notifications) of all notifications submitted to the system during the period indicated. The combined data were then processed in Microsoft Excel 365 (Microsoft Corporation, Redmond, DC, USA) and LibreOffice Calc 7.6.6.3 (The Document Foundation, Berlin, Germany) using the following functions: vertical search, pivot tables, filtering, sorting, and transposition.

The data for the ten most frequently reported hazards were then selected, and these covered 19,071 notifications (71.8%) of all the notifications reported as border rejections over the period of 2008–2023. These data were placed in source tables with particular years in the rows and product categories, notifying countries and countries of origin in the columns (three separate tables for each hazard). They were then transferred to Statistica 13.3 (TIBCO Software Inc., Santa Clara, CA, USA), where they were subjected to two-way joining cluster analysis to indicate similarities in reported border rejections. The number of columns with data was limited to 30 to increase the readability of the charts generated in this analysis. Two-way joining cluster analysis is an example of a multivariate analysis already used by the authors in their previous studies on RASFF notifications [17,18]. Large datasets involving RASSF notifications have also been studied using, for example, Bayesian networks [19–21], neural and non-neural machine learning models [22], or network analysis [23].

Two-way joining cluster analysis is useful in circumstances such as these, where one might expect that the data contained in either the rows (cases) or columns (variables) of the source tables might simultaneously contribute to the discovery of meaningful patterns of clustering once the charts have been generated. The structure of the outputs (clusters) resulting from this analysis is not homogeneous; nevertheless, it can be considered a powerful tool for data exploration [24] as it enables the extraction of patterns from large datasets [25]. The outcome of the two-way joining cluster analysis is a reorganised data matrix [26] presented in two-dimensional charts. They show the clusters as coloured squares, starting from white (no or smallest clusters) to green (various shades), yellow, orange, red, and finally brown (largest clusters). Charts containing the results of this analysis are included in the Supplementary Material in Figures S1–S10, depicting the ten most frequently reported hazards under border rejections. Each of these figures is composed of four panels: (a) the number of notifications related to a particular hazard for the period of 2008–2023 and the results of the two-way joining cluster analysis over this period for (b) product categories, (c) notifying countries, and (d) countries of origin.

The second stage of this study was to identify the food products imported in the largest quantities into the European Union according to the Eurostat database, using the option "Extra-EU (= 'WORLD' - 'EU_INTRA')" [2]. According to the Food and Agriculture Organization of the United Nations (FAO), food consists of commodities listed in the Standard International Trade Classification (SITC) in sections 0 (Food and live animals), including also division 08 (Feeding stuff for animals), 1 (Beverages and tobacco), 4 (Animal and vegetable oils, fats and waxes), and division 22 (Oil-seeds and oleaginous fruits). The particular divisions represent the types of food products [27,28]. Identification of the largest importers in the EU and countries of origin (exporters to the EU) was also carried out. In carrying out this analysis, the subtotal, sorting, and transposition functions in Microsoft Excel 365 were used, as well as two-way joining cluster analysis in Statistica 13.3 with food product in the rows and notifying countries and countries of origin in the columns. For the presentation of the results, sections 0, 1 and 4 were divided. However, only the ten most frequently reported products (out of a total of sixteen) are presented in order to make the charts more readable. The obtained findings were then linked to the RASFF notification analysis carried out earlier.

Link visualisations (maps) of the keywords contained in the phrase "'European Union' OR EU AND food AND import" were also constructed. For this, a search was first carried out on the Web of Science (WoS) website for scientific works containing these words, then the number of results was further reduced using the narrowing criteria "author keywords" and the period of 2008–2023. Finally, 16,450 results (scientific works) were obtained, and the retrieved bibliographic data were exported as text files [29]. These data were then analysed in VOSviewer 1.6.20 (Centre for Science and Technology Studies, Leiden University, Leiden, The Netherlands). The following options were used: type of analysis (co-occurrence), unit of analysis (author keywords), counting method (full counting), and threshold, i.e., minimum number of occurrences of a keyword: 115. This number was gradually increased in order to enhance the readability of the maps generated, i.e., the network visualisation and the overlay visualisation.

3. Results

3.1. Hazards Reported in the RASFF as Border Rejections

The ten most frequently reported hazards notified in the RASFF as border rejections in 2008–2023 are presented in Table 1 in descending order. The three most frequently raised hazards, i.e., aflatoxins, pesticides, and *Salmonella* spp., accounted for nearly 60% of all notifications reported as border rejections.

Table 1. The ten most frequently reported hazards in the RASFF as border rejections in 2008–2023.

Hazard	Hazard Category (Categories)	Number of Notifications	Percentage
Aflatoxins	Mycotoxins, migration	6719	25.30%
Pesticide(s)	Pesticide residues	5515	20.80%
Salmonella spp.	Pathogenic micro-organisms, Non-pathogenic micro-organisms	3279	12.30%
Poor temperature control	Poor or insufficient controls	922	3.50%
Health certificate(s)	Adulteration/fraud	793	3.00%
Colour	Food additives and flavourings, migration, composition	474	1.80%
Chromium	Migration	374	1.40%
Ochratoxin A	Mycotoxins	327	1.20%
Mould(s)	Microbial contaminant(s)	348	1.20%
Sulphite(s)	Food additives and flavourings, allergens	321	1.20%
Total		**19,071**	**71.80%**
Other hazards		**7493**	**28.20%**

Table 2 shows the ten mentioned hazards, considering year(s), product category, notifying country, and country of origin. These are the results of a two-way joining cluster analysis, taking into account the most relevant clusters (usually red and brown). Charts depicting the outcomes of this analysis are included in the Supplementary Material in Figures S1–S10 in panels a–d.

Aflatoxins (belonging to mycotoxins) were notified in 2008–2010 by The United Kingdom and The Netherlands in nuts from China, Iran and Turkey. In turn, ochratoxin A (also included in mycotoxins) was reported in 2018–2019 and 2022 by Poland, France, The Netherlands, and Italy in fruits and vegetables from Turkey.

Pesticides were claimed in 2012–2013 and also more recently (2020–2022) by the United Kingdom and Bulgaria in fruits and vegetables from India and Turkey, respectively. The commonly communicated pesticides were chlorpyrifos, acetamiprid, chlorpyrifos-methyl, formetanate, carbendazim, dimethoate, triazophos, acephate, methomyl, and ethylene oxide. However, it should be noted that often, two or more pesticides were notified within a single notification (more than 200 pesticides were reported singly or in combination with others).

Salmonella spp. was declared by The Netherlands in poultry meat from Brazil in 2017, by Greece in nuts from Sudan in 2019, and by Germany in herbs and spices from Brazil in 2021. In turn, moulds were reported by Poland in products from Ukraine. These notifications related to feed materials in 2010, 2021, and 2023 and to fruits and vegetables in 2021.

Other hazards among the ten most frequently communicated were mainly reported in earlier years. These were related to poor temperature control in fish from Mozambique, Peru, China, and Morocco, adulteration of health certificates for nuts, herbs, and spices from India, colours in cereals and bakery products from the United States, migration of chromium from food contact materials from China, and the presence of sulphites in fruits and vegetables from Turkey.

The data from the restored (archived) database (i.e., for the years 2008–2021) can also provide information on the notification basis and the action taken. The notification basis was mainly border control, after which the consignment was detained (in more than 95% of cases). In turn, the most common actions taken were re-dispatch, destruction, official detention, and unauthorised imports. Unfortunately, there are no such data available when the file is exported from the currently official RASFF database (i.e., for the years 2022–2023).

In order to obtain them, one would have to separately view the details of each notification directly on the website of this database.

Besides the hazards indicated in Tables 1 and 2, other notified hazards were, for example (in descending order and over 100 notifications), migration of nickel, manganese, primary aromatic amines, or the presence of heavy metals such as mercury or cadmium, organoleptic aspects (including spoilage) and poor hygienic state, foreign bodies such as insects and mites, adulteration of imports and reports, micro-organisms such as *Escherichia coli* or *Enterobacteriaceae*, as well as the presence of histamine as a biological contaminant, parasitic infestation by *Anisakis*, inappropriate composition (content of Sudan dye or aluminium), nitrofuran metabolites as residues of veterinary medicinal products, defective or incorrect packaging or missing, incomplete, or incorrect labelling, genetic modifications, and irradiation.

Table 2. The results of two-way joining cluster analysis for the ten most frequently notified hazards reported in the RASFF as border rejections in 2008–2023.

Hazard (Figure)	Year(s) (Panel a)	Product Category (Panel b)	Notifying Country (Panel c)	Country of Origin (Panel d)
Aflatoxins (Figure S1)	2008	Nuts, nut products, and seeds	The United Kingdom	China, Iran
	2008–2010		The Netherlands	Turkey
Pesticide(s) (Figure S2)	2012–2013	Fruits and vegetables	The United Kingdom	India
	2020–2022		Bulgaria	Turkey
Salmonella spp. (Figure S3)	2017	Poultry meat and poultry meat products	The Netherlands	Brazil
	2019	Nuts, nut products, and seeds	Greece	Sudan
	2021	Herbs and spices	Germany	Brazil
Poor temperature control (Figure S4)	2011	Fish and fish products	Spain	Mozambique, Peru
	2018			China
	2011–2012, 2018–2019			Morocco
Health certificate(s) (Figure S5)	2016–2017	Nuts, nut products, and seeds Herbs and spices	The United Kingdom	India
Colour (Figure S6)	2020	Cereals and bakery products	The United Kingdom	The United States
Chromium (Figure S7)	2010–2014	Food contact materials	Italy	China
Ochratoxin A (Figure S8)	2018	Fruits and vegetables	Poland	Turkey
	2019		France, The Netherlands, Poland	
	2022		Italy, The Netherlands	
Mould(s) (Figure S9)	2010, 2021, 2023	Feed materials	Poland	Ukraine
	2021	Fruits and vegetables		
Sulphite(s) (Figure S10)	2015–2017	Fruits and vegetables	Bulgaria	Turkey
	2016–2018		Spain	

3.2. Food Imported by the European Union According to Eurostat

Figure 2 shows EU food imports in 2008–2023 according to Eurostat, considering the SITC divisions by quantity [2]. In turn, Figures 3 and 4 demonstrate the import of food products during the period indicated by importing country and country of origin (exporters to the EU), respectively. The 30 largest exporters are included.

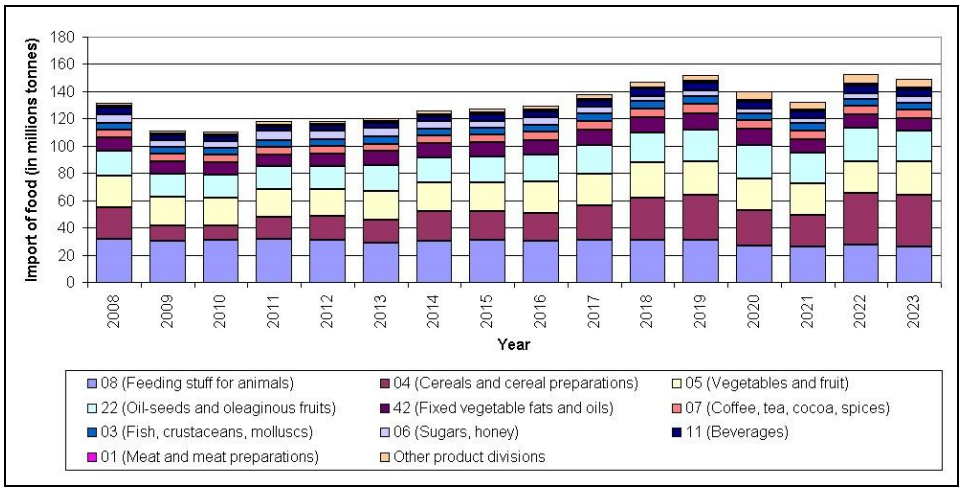

Figure 2. EU food import in 2008–2023 by quantity according to Eurostat. Explanation of abbreviations used: 03 (Fish, crustaceans, molluscs)—03 (Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof), 06 (Sugars, honey)—06 (Sugars, sugar preparations and honey), 07 (Coffee, tea, cocoa, spices)—07 (Coffee, tea, cocoa, spices, and manufactures thereof), 08 (Feeding stuff for animals)—08 (Feeding stuff for animals (not including unmilled cereals)), 42 (Fixed vegetable fats and oils)—42 (Fixed vegetable fats and oils, crude, refined or fractionated).

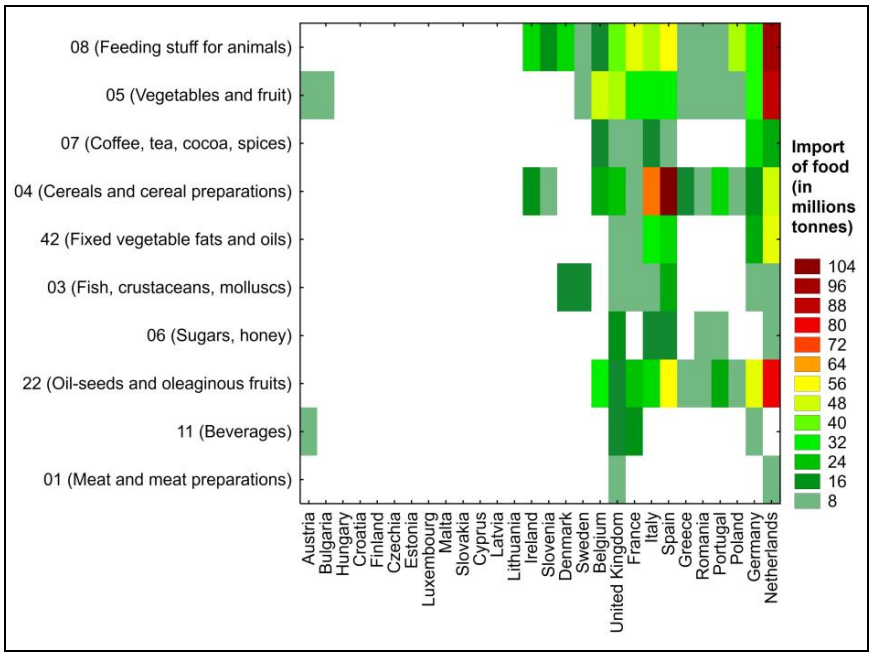

Figure 3. EU food importing countries in 2008–2023 by quantity according to Eurostat. Explanation of abbreviations used: 03 (Fish, crustaceans, molluscs)—03 (Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof), 06 (Sugars, honey)—06 (Sugars, sugar preparations and honey), 07 (Coffee, tea, cocoa, spices)—07 (Coffee, tea, cocoa, spices, and manufactures thereof), 08 (Feeding stuff for animals)—08 (Feeding stuff for animals (not including unmilled cereals)), 42 (Fixed vegetable fats and oils)—42 (Fixed vegetable fats and oils, crude, refined or fractionated).

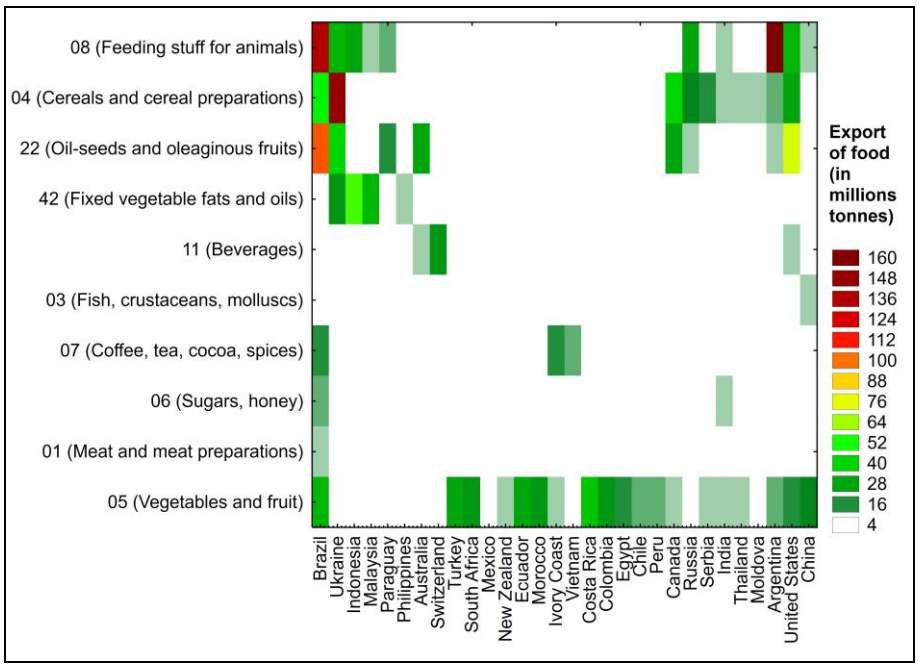

Figure 4. Major food exporters to the EU in 2008–2023 by quantity according to Eurostat. Explanation of abbreviations used: 03 (Fish, crustaceans, molluscs)—03 (Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof), 06 (Sugars, honey)—06 (Sugars, sugar preparations and honey), 07 (Coffee, tea, cocoa, spices)—07 (Coffee, tea, cocoa, spices, and manufactures thereof), 08 (Feeding stuff for animals)—08 (Feeding stuff for animals (not including unmilled cereals)), 42 (Fixed vegetable fats and oils)—42 (Fixed vegetable fats and oils, crude, refined or fractionated).

During the period under study, import of food considered by volume increased, although a slight decline could be observed during the COVID-19 pandemic, i.e., between 2020 and 2021. The main imports were feed for animals, cereals and cereal preparations, fruits and vegetables, oil-seeds and oleaginous fruits, and fixed vegetable fats and oils (Figure 2).

The largest food importers during the study period (2008–2023) were Western European countries, i.e., the United Kingdom, France, Italy, Spain, Germany, and The Netherlands (the major concentration of clusters occurred here). It is worth noting here that the Pearson correlation coefficient between the mean population in importing countries (in millions) [30] and the mean quantity of food imported (in millions of tonnes) [2] was 0.67 (test statistic = 4.61, exceeding the critical statistic = 2.06 by $\alpha = 0.05$ in the two-tailed distribution). This indicates a moderate correlation [31]. The reason this correlation is not higher may be due to ongoing re-exports within the EU. All of the mentioned countries imported feed for animals, fruits and vegetables, coffee, tea, cocoa and spices, cereals and cereal preparations, fixed vegetable fats and oils, fish, crustaceans and molluscs, and oil-seeds and oleaginous fruits. However, special attention should be paid to the largest clusters, i.e., feed for animals, fruits and vegetables, and oil-seeds and oleaginous fruits imported by The Netherlands, as well as cereals and cereal preparations imported by Italy and Spain. It should be emphasised that The Netherlands was the first importer of animal feed, fruits and vegetables, and oil-seeds from outside the EU and also the first or second exporter of these products within the EU. In turn, Italy and Spain imported the most cereals from outside the EU into the common market [32]. Some of the products mentioned were also imported by Belgium, Greece, Romania, Portugal, and Poland (Figure 3).

In turn, as far as the countries of origin of the imported products are concerned, the following are particularly noteworthy: feeding stuff for animals exported by Brazil and

Argentina, oil-seeds and oleaginous fruits from Brazil, and cereals and cereal preparations exported by Ukraine. These products were also exported by other countries. However, it should also be pointed out that the most diverse in terms of origin were fruits and vegetables (Figure 4). It is worth noting that due to the larger quantities represented by some of the clusters (which can be concluded from the legend), the greater part of this chart contains smaller clusters, marked in white.

By comparing the results of the analysis of data extracted from the RASFF and from Eurostat, it can be concluded that fruits and vegetables are the most likely to carry hazards (according to the SITC, this product group also includes nuts). However, other imported products in which hazards may also be found are cereals, cocoa, coffee and tea, herbs and spices, fish, poultry meat, and feed. It is worth noting at this point that despite the significant imports of feed into the European Union, analysis of RASFF data did not reveal a significant number of notifications in this respect (compared to the most frequently notified products). This implies that the countries exporting these products (mainly Brazil and Argentina) attach considerable importance to ensuring that they are free of hazards. However, on the other hand, the number and scope of controls carried out by EU member state supervisory authorities may be lower than in relation to food.

3.3. Visualisations of Links Between Keywords in VOSviewer

Figures 5 and 6 show visualisations of network and overlay, respectively, generated in VOSviewer 1.6.20. They were created using data exported from WoS after a search for scientific publications from 2008–2023 based on the phrase "'European Union' OR EU AND food AND import" [29]. These keywords were indicated by the authors alongside others that are visible in the visualisations.

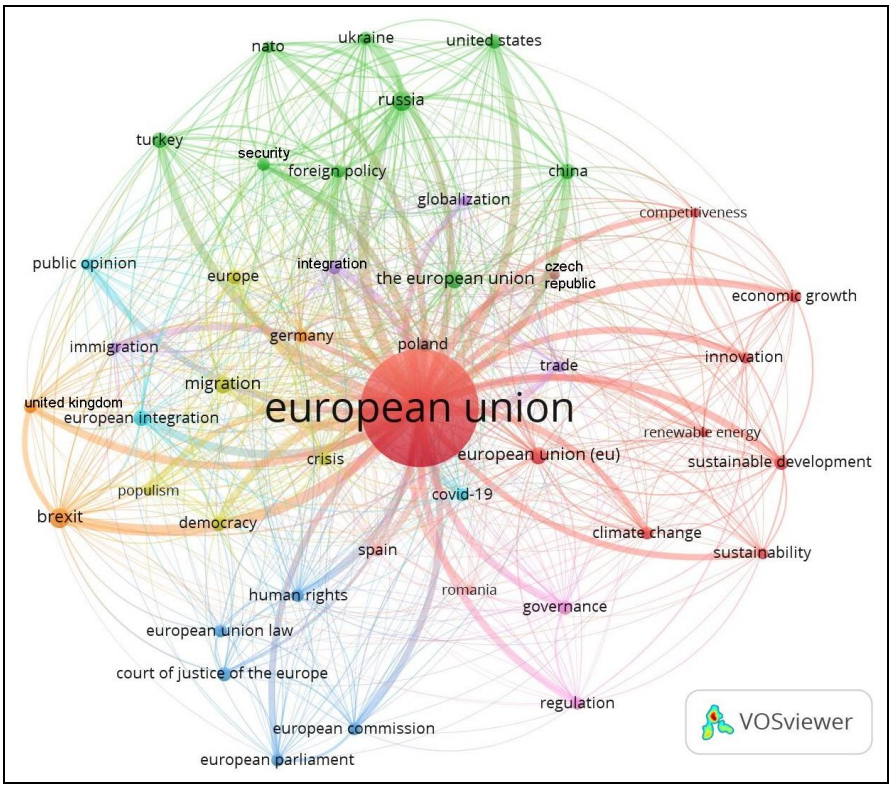

Figure 5. Network visualisation generated in VOSviewer.

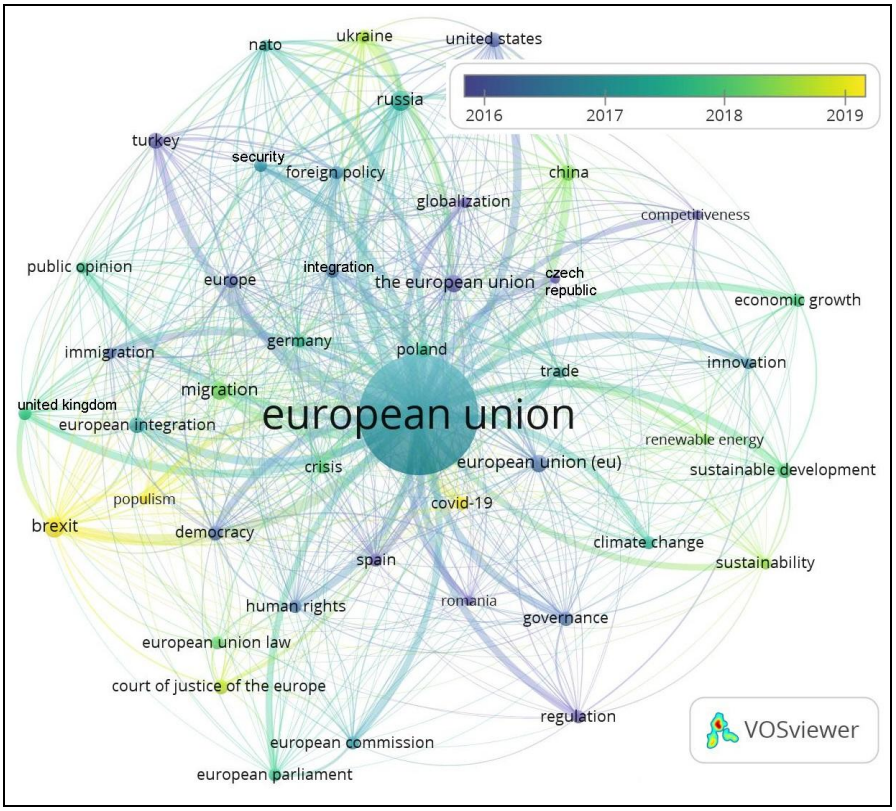

Figure 6. Overlay visualisation generated in VOSviewer.

The network visualisation (Figure 5) depicts clusters marked with different colours. The most prominent is the red cluster with the word "european union" in the centre of the map. It is combined with words such as "european union (eu)", "competitiveness", "economic growth", "innovation", "renewable energy", "climate change", "sustainability", and "sustainable development". The dark purple cluster contains similar items, i.e., "integration", "immigration", "globalization", and "trade". This indicates that food imports are economically driven and are also linked to environmental changes. In turn, the dark blue cluster points to legal aspects including: "european union law", "european commission", "european parliament", "court of justice of the europe", and "human rights". It can therefore be inferred that the European Union as an institution seeks to be proactive in establishing regulations for imported food.

European countries importing food are located in the pink cluster (Spain and Romania), the brown cluster (Poland), and above all in the orange cluster, including Germany and the United Kingdom. These two countries, as well as Spain, frequently reported notifications regarding hazards in food (Table 2) and were also among its main importers (Figure 3). However, it is also worth noting that there is a "brexit" item in the orange cluster, which may indirectly indicate that the exit of the United Kingdom from the European Union has contributed to the decline in food imports. Indeed, in 2020 and 2021, i.e., immediately after Brexit, a decline in food import can be observed (Figure 2). However, it should also be noted that the COVID-19 outbreak started at the same time. This item (i.e., "COVID-19") is in the light-blue cluster, together with "european integration" and "public opinion".

The green cluster includes countries exporting food to the European Union, including Turkey, China, The United States, Ukraine, and Russia. The first four countries mentioned were notified as sources of foods containing hazards (Table 2). The other elements found in this cluster are also worth noting, i.e., "the european union", "foreign policy", "nato", and "security". The close link between NATO (North Atlantic Treaty Organization) and security

in terms of food seems particularly interesting. From this, it can be concluded that NATO contributes to guaranteeing the availability of food in the European Union. However, it is also worth recalling at this point that the EU has a food trade surplus (Section 1). It is worth adding at this point that, according to the NATO Maritime Strategy, in the context of food security, the Allies are interested in freedom of navigation, maritime trade routes, protection of marine resources, environmental safety, and infrastructure protection [33].

In Figure 6, the keywords indicated by the authors in recent years are shown in yellow (i.e., from 2019 onwards, as shown in the legend at the top right of the map) in terms of food imported into the European Union. The authors pointed out that in these years, the impact on EU food imports was mainly driven by Brexit and COVID-19. Determinants related to these issues already have been addressed. However, it is also worth noting that Ukraine is also marked in yellow, which means that the war waged by Russia has been of interest to authors of scientific publications if we relate this to food imports. Two other yellow items are also visible, i.e., "court of justice of the europe" (indicating that this body has been particularly active in recent years) and "populism". In the context of populism, it is worth mentioning ethnocentrism. In recent years, there has been a noticeable increase in ethnocentric attitudes in Europe [34,35]. Within the framework of the EU CAP, special support measures have been established for the development and promotion of local food systems within the framework of national and regional rural development programmes [36]. Globalisation has led to rapid access to food from the most remote areas. However, it has also hampered the development of local small-scale food producers who do not have the resources for advertising and marketing. This problem has been particularly acute during the COVID-19 pandemic [37,38]. Studies conducted in various countries have confirmed the effectiveness of short food supply chains (SFSC) in crisis situations [34,35,39,40]. The awareness of society in purchasing food from local producers is growing, and social bonds are being created between food producers and consumers [41,42].

4. Discussion

Anyogu et al. (2024) pointed out that foodborne hazards not only pose potential health risks to consumers but also hinder international trade due to border rejections and increased import controls [43]. The EU's overarching policy for imported food is to reduce non-compliant food through border controls and audits in exporting countries [44]. Major seaports or air traffic hubs play an important role in terms of EU food safety and food security policies [45]. It is worth noting that EU requirements regarding food may be stricter than those set by the World Trade Organization (WTO) [46]. However, exporting countries should test a consignment before it is exported to the EU to avoid border rejection [44]. It is important to point out that for the exporter, this means lost earnings, transportation and insurance costs, and damage to reputation, which can affect competitiveness [46]. It is also worth mentioning that such shipments are often destroyed by the importing country [47]. In fact, each individual case means economic losses and food waste for the exporter involved, but the main problem is the overall loss of confidence by EU buyers with regard to food safety and quality [48].

Due to its geographic proximity and land border with two EU countries, Bulgaria and Greece, it is worthwhile—in the context of border rejections—to pay attention to Turkey. This country is a major producer and exporter of fresh fruits and vegetables in the world [49], and these are strategically important in terms of trade with the EU [50]. It is highlighted that a full surveillance system for fresh produce is needed in Turkey, such as with regard to *Salmonella* spp. [49]. It is also recommended that the General Directorate of Food and Control implement a pesticide residue monitoring program in Turkey, especially regarding fruits and vegetables [51]. In turn, the example of Chinese companies shows that

due to border rejections, some of them have stopped exporting to the European market, while others have entered it. It is worth noting here that small companies are more affected by this phenomenon [52], so it can be inferred that border rejections eliminate them from trade to some extent.

4.1. Border Rejections in Studies on the RASFF and Food Imports

The five most frequently reported product categories and hazard categories notified within border rejections and published in RASFF annual reports for 2008–2019 are shown in Table 3. These categories are given in descending order of the number of notifications in a given year. In the annual report for 2020, no such overview was published. It is also worth mentioning that from 2021 onwards, the annual reports have been issued not as RASFF reports but as ACN reports. They are much shorter and more general, and they do not contain any more detailed overviews of notifications.

Table 3. The five most frequently reported product categories and hazard categories notified within border rejections and published in RASFF annual reports for 2008–2019.

Year	Product Categories	Hazard Categories	Reference
2008	Nuts and seeds, fruits and vegetables, fish, cereals and bakery, food contact materials	Mycotoxins, food additives, heavy metals, pathogenic micro-organisms, veterinary medicines	[53]
2009	Nuts and seeds, fish, fruits and vegetables, crustaceans, food contact materials	Mycotoxins, pathogenic micro-organisms, insufficient controls, heavy metals, veterinary medicines	[54]
2010	Nuts and seeds, fruits and vegetables, fish, herbs and spices, food contact materials	Mycotoxins, insufficient controls, pesticide residues, pathogenic micro-organisms, heavy metals	[55]
2011	Nuts and seeds, fruits and vegetables, fish, feed materials, food contact materials	Mycotoxins, pesticide residues, insufficient controls, foreign bodies, pathogenic micro-organisms	[56]
2012	Fruits and vegetables, nuts and seeds, fish, food contact materials, feed materials	Mycotoxins, pesticide residues, pathogenic micro-organisms, insufficient controls, heavy metal	[57]
2013	Fruits and vegetables, nuts and seeds, food contact materials, poultry meat, fish	Pesticide residues, pathogenic micro-organisms, mycotoxins, heavy metals, adulteration/fraud	[58]
2014	Fruits and vegetables, nuts and seeds, food contact materials, fish, poultry meat	Mycotoxins, pesticide residues, pathogenic micro-organisms, heavy metals, adulteration/fraud	[59]
2015	Fruits and vegetables, nuts and seeds, food contact materials, herbs and spices, fish	Mycotoxins, pesticide residues, pathogenic micro-organisms, adulteration/fraud, heavy metals	[60]
2016	Nuts and seeds, fruits and vegetables, herbs and spices, fish, food contact materials	Mycotoxins, pathogenic micro-organisms, pesticide residues, adulteration/fraud, insufficient controls	[61]
2017	Nuts and seeds, poultry meat, fruits and vegetables, fish, herbs and spices	Mycotoxins, pathogenic micro-organisms, adulteration/fraud, pesticide residues, insufficient controls	[62]

Table 3. *Cont.*

Year	Product Categories	Hazard Categories	Reference
2018	Nuts and seeds, fruits and vegetables, fish, feed materials, poultry meat	Mycotoxins, pathogenic micro-organisms, pesticide residues, insufficient controls, adulteration/fraud	[63]
2019	Nuts and seeds, fruits and vegetables, herbs and spices, feed materials, fish	Mycotoxins, pathogenic micro-organisms, pesticide residues, adulteration/fraud, insufficient controls	[64]

Explanation of abbreviations used for product categories: Cereals and bakery—Cereals and bakery products, Crustaceans—Crustaceans and products thereof, Fish—Fish and fish products, Nuts and seeds—Nuts, nut products and seeds, Poultry meat—Poultry meat and poultry meat products. Explanation of abbreviations used for hazard categories: Insufficient controls—Bad or insufficient controls and Poor or insufficient controls, Veterinary medicines—Residues of veterinary medicinal products.

In each of the years from 2008–2019, nuts, nut products and seeds, and fruits and vegetables were among the most frequently reported product categories (mostly in first or second place), as well as fish and fish products. Between 2008 and 2016, food contact materials were submitted, and additionally, in different years, herbs and spices, poultry meat and poultry meat products, and feed materials were also notified. Despite the shorter period, the product categories listed in Table 3 therefore overlap with those indicated in Figure 1. Visciano and Schirone (2021), analysing border rejections reported in the RASFF between 2015 and 2020, also noted that the following product categories were most frequently notified: nuts and seeds, fruits and vegetables, herbs and spices, and fish and fish products [65]. In turn, Banach (2016) highlighted herbs and spices reported between 2004 and 2014 [66].

Meanwhile, in terms of hazard categories, in each year of the 2008–2019 period, mycotoxins and pathogenic micro-organisms were reported, and in 2010–2019, pesticide residues were also notified. Also, a significant concern was adulteration/fraud (in 2013–2019) and poor or insufficient controls. The hazard categories listed in Table 3 correspond to those in Table 1. It is also worth noting that very often, heavy metals are mentioned in Table 3 and do not appear in Table 1. The reason for this may be the reporting of different heavy metals in different products and the resulting scattering of notifications. Analysis regarding border rejections reported in the RASFF carried out by Papapanagiotou (2021a) for the years 2012–2019 indicated similar most frequently notified hazard categories, namely mycotoxins, pathogenic micro-organisms, pesticide residues, microbial contaminants (other), and metals [13].

Mycotoxins reported in the RASFF under border rejections were a frequently noted problem. Already, between 2008 and 2010, a significant number of border rejections were linked to the presence of mycotoxins in pistachios from Iran and hazelnuts, dried figs, pistachios, and raisins from Turkey. However, it is worth noting that mycotoxins in dried figs from this country were frequently reported as border rejections over a much longer time horizon, namely 2002–2019 [67]. Marín et al. (2013) and Brera et al. (2014) pointed out that mycotoxins were the most frequently reported hazard submitted in 2012 [68,69]. Similarly, Marín and Ramos (2016) noted that it was the main hazard identified in the 2014 RASFF annual report [70]. Alshannaq and Yu (2021) highlighted border rejections concerning American nuts (pistachios, almonds, and peanuts) between 2010 and 2019 due to aflatoxin contamination [71]. In turn, Mukhtar et al. (2023) noted an increasing number of border rejections concerning African staple crops due to the presence of aflatoxins [72]. However, Turkey, China, and India were the most frequently reported countries of origin for aflatoxin-contaminated food in the RASFF under border rejections between 1997 and

2022 [6]. Anyogu et al. (2024) noted that mycotoxin-contaminated sesame seeds can have serious economic consequences due to border rejections and recalls [43].

Eissa et al. (2024b) [8], after analysing border rejections reported in the RASFF on fruits and vegetables between 1999 and 2022, found that they were mainly reported by Germany and Bulgaria and originated from Turkey and India (similar countries are also indicated in Table 2). In this context, they indicated pesticides such as chlorpyrifos, dimethoate, carbendazim, chlorpyrifos-methyl, and omethoate [8]. Kareem et al. (2017) [73] pointed out that rejections at the EU border for exceeding pesticide residue limits resulted in revenue losses for African exporters. Between 2008 and 2013, border rejections affected 70% of African fruits and vegetables, indicating a significant problem in accessing the European market [73]. Products containing unauthorised pesticide residues that are rejected at the EU border are destroyed, re-dispatched, or subject to special treatment [74]. Kuchheuser and Birringer (2022a) [75] noted that import controls and border rejections appear to be an effective means of protecting European consumers from products originating from third-party countries and containing pesticide residues. However, the problem also includes non-compliance and harmful products from EEA countries, and this may require further action in the EU market [75].

Anyogu et al. (2024), referring to imported sesame-based foods infected with *Salmonella* spp., noted that this has serious consequences, including border rejections, recalls, and outbreaks [43]. Somorin et al. (2021) [76], analysing notifications reported in the RASFF between 1999 and 2019 on products from Africa, found that most of them were submitted as border rejections and were related to the presence of pathogenic micro-organisms (mainly *Salmonella* spp.). They noted that these mainly involved nuts, nut products, and seeds from Sudan and were reported by Greece [76]. In turn, D.'Amico et al. (2018) [77] pointed out that border rejections of seafood reported in the RASFF between 2011 and 2015 mainly referred to poor temperature control, unsuitable transport conditions, and a fraudulent/absent health certificate. They added that border posts find it easier to control temperature or documentation than other hazards [77]. Eissa and Younes (2024) found that of all types of notifications reported in the RASFF on fish in the period of 2000–2022, about one-quarter involved border rejections [9]. Eissa et al. (2023) also found that when it related to food contact materials, chromium had the highest number of border rejections during the same period (i.e., 2000–2022) [12].

However, the hazards outlined above should be linked to the quantity of imports. Table 4 shows the ten most imported food products by quantity and the ten largest importers of these products in the EU by the SITC from 2008 to 2023 in descending order.

The following products were mainly imported: feed (23%), cereals (18%), fruits and vegetables (17%) (this division also includes nuts), oil-seeds and oleaginous fruits (15%), and fixed vegetable fats and oils (8%). Other imports included coffee, tea, cocoa and spices, fish, crustaceans and molluscs, sugars and honey, beverages, meat, and other product divisions (a total of 19% of all imports). In turn, as already noted in Section 3.2, the largest food importers between 2008 and 2023 were Western European countries. In descending order of import volume, these were The Netherlands (20% of EU food imports), Spain (15%), Italy (11%), Germany (10%), The United Kingdom (8%), and France (8%).

It should also be pointed out that, with very few exceptions, all mentioned countries were among the top ten importers of all types of products (i.e., all divisions). However, due to Brexit, the United Kingdom can be excluded from further consideration regarding the most significant hazards already identified (Table 2). Thus, taking into account the quantity of imports and hazards, particular attention should be paid to products imported by the following countries:

- The Netherlands: nuts from Turkey (in terms of aflatoxins), fruits and vegetables from Turkey (ochratoxin A), and poultry from Brazil (*Salmonella* spp.);
- Spain: fish from China and Morocco (poor temperature control) and fruits and vegetables from Turkey (sulphites);
- Italy and France: fruits and vegetables from Turkey (ochratoxin A);
- Germany: spices from Brazil (*Salmonella* spp.).

Table 4. The ten most imported food products by quantity and the ten largest importers of these products in the EU by the SITC from 2008 to 2023.

Food Product (Code and Division)	Percentage of Import	Importing Countries
08 (Feed for animals)	23%	The Netherlands, Spain, France, Italy, Poland, The United Kingdom, Germany, Ireland, Denmark, Slovenia
04 (Cereals and cereal preparations)	18%	Spain, Italy, The Netherlands, Portugal, The United Kingdom, Belgium, Ireland, Germany, Greece, Poland
05 (Vegetables and fruit)	17%	The Netherlands, Belgium, The United Kingdom, Germany, Italy, Spain, France, Poland, Greece, Romania
22 (Oil-seeds and oleaginous fruits)	15%	The Netherlands, Spain, Germany, Belgium, Italy, France, Portugal, The United Kingdom, Poland, Greece
42 (Fixed vegetable fats and oils)	8%	The Netherlands, Italy, Spain, Germany, France, The United Kingdom, Poland, Belgium, Sweden, Denmark
07 (Coffee, tea, cocoa, spices)	4%	Germany, The Netherlands, Italy, Belgium, France, Spain, The United Kingdom, Poland, Sweden, Finland
03 (Fish, crustaceans, molluscs)	4%	Spain, Sweden, Denmark, The Netherlands, Germany, Italy, France, The United Kingdom, Poland, Portugal
06 (Sugars, honey)	4%	The United Kingdom, Spain, Italy, Portugal, Romania, The Netherlands, France, Germany, Belgium, Ireland
11 (Beverages)	3%	France, The United Kingdom, Germany, Austria, The Netherlands, Ireland, Sweden, Belgium, Spain, Slovenia
01 (Meat and meat preparations)	1%	The Netherlands, The United Kingdom, Germany, France, Italy, Spain, Belgium, Ireland, Sweden, Romania
Other product divisions	3%	The Netherlands, Germany, France, Spain, the United Kingdom, Ireland, Belgium, Denmark, Poland, Italy

Moulds in feed materials and fruits and vegetables notified by Poland in products from Ukraine are also worth noting. Ukraine is a border country for the European Union with an ongoing war, so exports of products via Poland may currently be an important source of income for Ukraine. Additionally, due to its geographical proximity, it is also notable that pesticides and sulphites were declared in fruits and vegetables imported by Bulgaria from Turkey. Finally, it is important to indicate that due to the EU common market and the free movement of products within internal trade, they may have been subject to the re-export already mentioned. The comparison of quantities of mean food imports from outside the EU and exports within the EU in 2008–2023 according to the SITC (Eurostat) [32] is presented as a radar chart (Figure 7). The mean for The United Kingdom is given for the period of 2008–2019 due to a lack of data for this country from 2020 onwards in Eurostat.

It should be remembered that that The Netherlands was by far the largest importer of food from outside the EU, followed by Spain, Italy, Germany, and France. In turn, the largest food exporters (also in descending order) within the EU were Germany, France, The Netherlands, Belgium, Spain, and Italy. It is also worth pointing out that the difference

between imports from outside the UE and exports to the single market for The Netherlands was smaller than for Germany and France. What is also interesting is that The United Kingdom (when this country was a member of the EU) was the only one of the larger EU countries that imported more food from outside than it exported within the EU.

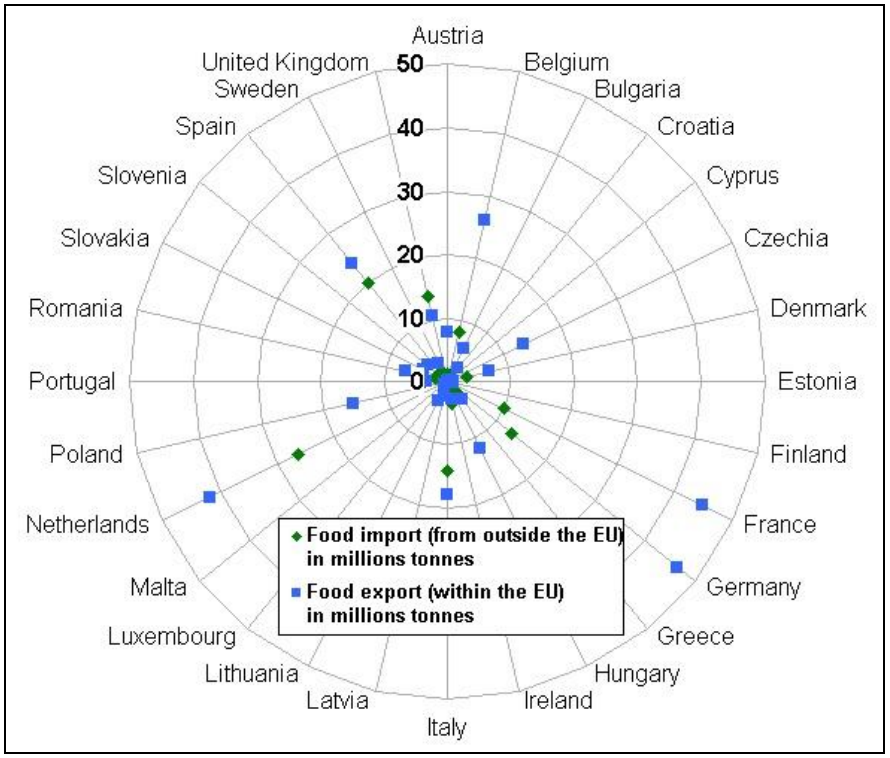

Figure 7. Comparison of quantities of mean food imports from outside the EU and exports within the EU in 2008–2023 according to Eurostat.

4.2. Health Implications of the Most Commonly Reported Hazards

The ten most frequently reported hazards reported in RASFF as border rejections were chemical hazards (mycotoxins: aflatoxins, ochratoxin A, and moulds related to them, pesticides, additives: colours and sulphites, and chromium), microbiological hazards (*Salmonella* spp.), and lack of proper temperature control of the food product and falsification of health certificates.

4.2.1. Mycotoxins: Aflatoxins, Ochratoxin A, and Moulds

Papapanagiotou (2021a) examined border rejections reported in the RASFF between 2012 and 2019, where the risk of hazards in the product was identified as serious for health, and found that although more than 53% of such notifications were for mycotoxins, the vast majority of these were not reported in the first ten days after sampling, which is very worrying [13]. According to this study, aflatoxin contamination was found mainly in 2008–2010 in nuts and products containing nuts and seeds. The presence of aflatoxins is all the more dangerous because nuts and products containing nuts and seeds are extremely popular ingredients in many diets. Their consumption is increasing due to the popularity of vegan, vegetarian, flexitarian, and other diets [78]. The beneficial effects of nuts and seeds have been documented in treating and reducing the risk of chronic diseases such as cardiovascular disease, type 2 diabetes, non-alcoholic fatty liver disease, and cognitive impairment. The health benefits associated with the consumption of nuts and seeds do not exempt us from conducting toxicological and epidemiological studies on mycotoxins [79]. Aflatoxins are mycotoxins produced by moulds such as *Aspergillus parasiticus* and *Aspergillus flavus*, which

develop throughout the logistics chain from farm to fork, and their growth is particularly favoured by improper storage in a humid climate. Of the numerous aflatoxins, aflatoxin B1 is considered the most dangerous. Among other things, aflatoxins impair liver and other organ function, leading to cancer. In developed countries, average dietary exposure to aflatoxins is usually below 1 ng/kg body weight (bw) per day, while estimates for many countries in sub-Saharan Africa exceed 100 ng/kg bw per day [80]. Aflatoxin B1 has been classified as a Group 1 human carcinogen by the International Agency for Research on Cancer (IARC) [81].

Another mycotoxin reported in the RASFF in 2018–2022 was ochratoxin A (OTA). It is produced by several species of fungi, including *Aspergillus ochraceus*, *Aspergillus carbonarius*, *Aspergillus niger*, and *Penicillium verrucosum*. OTA-producing moulds grow on processed or unprocessed agricultural products, mainly cereals and cereal products, and also potatoes, legumes, nuts, spices, coffee, cocoa, beer, and wine. OTA has been found to cause nephrotoxicity and kidney tumours in various animal species. It is also responsible for a number of adverse health effects in humans, such as nephro-, neuro-, immuno-, and embryotoxicity, as well as muta- or teratogenicity [82,83]. Previous studies have linked OTA to the occurrence of endemic nephropathy and chronic interstitial nephropathy [84]. According to the IARC, OTA has been classified as a possible human carcinogen (Group 2B). The maximum limits of OTA vary greatly in different countries of the world depending on the type of product. The European Union has set a food OTA limit of 2 to 20 μg/kg for various products, while the FAO/WHO Codex Alimentarius suggests only a limit of 5.0 μg/kg for unprocessed cereal grains and 20 μg/kg for dried peppers. In turn, the United States has not set a limit for OTA [85].

4.2.2. Pesticides

Pesticides are a group of chemical compounds used in agriculture, horticulture, households, and other areas of the economy to control pests. Their task is to protect crops against fungi (fungicides), insects (insecticides), and weeds (herbicides). It is believed that the growth of the world's population would not be possible without a parallel increase in food production. In turn, a significant increase in food production would not be possible, among others, without pesticides. Without proper protection, more than half of the world's crops would be lost due to diseases, insects, and weeds [86]. Although pesticides are beneficial for crop production, their excessive use can have serious consequences for human health and the environment. Pesticides directly or indirectly pollute the air, water, soil, food, and the entire ecosystem, which poses a serious threat to the health of living beings [87–89]. Agricultural workers and people who have direct contact with pesticides are most exposed to the toxic effects of these substances if proper protection is not applied during their use. Pesticides can cause neurological abnormalities, reproductive problems, respiratory irritation, environmental disturbances, and the emergence of pest resistance [90].

The IARC has concluded that five common pesticides and herbicides—tetrachlorvinphos, parathion, malathion, diazinon, and glyphosate—used in commercial crops are probably carcinogenic [91]. Cavalier et al. (2023) [92] reviewed 63 epidemiological studies on pesticide exposure and cancer risk in humans published between 2017 and 2021. Based on their analysis, they concluded that there is sufficient evidence to implement policies and regulatory actions that will reduce human exposure to pesticides [92]. In turn, the FAO/WHO assessed 37 pesticides, estimating the maximum residue levels recommended for use as maximum residue limits (MRLs) by the Codex Committee on Pesticide Residues (CCPR). Supervised Trial Median Residues (STMRs) and highest residues (HRs) were also set as a basis for estimating dietary exposure to residues of the pesticides tested. The meeting of

the FAO/WHO also established new acceptable daily intakes (ADIs) and acute reference doses (ARfDs) for the pesticides assessed [93].

4.2.3. *Salmonella* spp., Other Pathogens, and Poor Temperature Control

Microbiological hazards are often mentioned among the hazards reported in the RASFF. *Salmonella* spp. can be found in products with high consumption in the EU, such as poultry meat, nuts, and spices. Symptoms of salmonellosis include gastroenteritis, abdominal cramps, bloody diarrhoea, fever, muscle pain, headaches, nausea, and vomiting. *Salmonella* spp. contamination is mainly associated with products such as poultry, feed, dried food, infant formula, and fruit and vegetable products [94]. *Salmonella* spp. infections are a serious health problem beyond Europe. In recent years, numerous outbreaks of *Salmonella* spp. have been reported worldwide, indicating that prevention and control programs need to be improved and greater surveillance of infectious diseases should be introduced. This requires more stringent controls at governmental and private levels. Workers involved in meat processing and ready-to-eat food play a key role in the spread of *Salmonella* spp. *Salmonella*-related diseases are particularly high in intensity, making them one of the most notorious zoonoses in the EU [95,96]. The European Food Safety Authority (EFSA) also draws attention to the emergence of resistance to commonly used antimicrobials frequently found in *Salmonella* and *Campylobacter* isolates from humans and animals. Increasing treatment trends have been observed in *Salmonella* and *Campylobacter* serovars associated with poultry [97].

Among the hazards reported in the RASFF as border rejections, poor temperature control of transported fish and fish products was indicated relatively often. Fish are a very perishable food product; therefore, storage methods that extend their shelf life should be used, ensuring their safety and quality from catch to consumption. Among the factors influencing the shelf life of fish, the most important are the species of fish and the stress experienced during fishing, as well as the time and temperature of storage. In addition, the method of storing fish (whole, filleted, or gutted) also affects the final quality of the product [98]. The spoilage process of fish and fish products occurs according to various mechanisms triggered by the metabolic activity of micro-organisms, endogenous enzymatic activity (autolysis), and chemical oxidation of lipids. As a result of these processes, there is a change in smell, taste, and texture, which occurs throughout the spoilage process [99].

One of the pathogenic factors resulting from non-compliance with the temperature regime for fish and fish products is the content of histamine. High concentrations of histamine lead to scombroid poisoning due to excessive growth and decarboxylase activity of histamine-producing bacteria. The main micro-organisms responsible for the production of histamine are bacteria belonging to the *Enterobacteriaceae* family and include both mesophilic and psychrotolerant genera, such as *Morganella*, *Enterobacter*, *Hafnia*, *Proteus*, and *Photobacterium*. Histamine poisoning is characterised by a wide range of symptoms, from a mild and self-limiting form with swelling and redness of the face, a burning sensation in the oral cavity, swelling of the tongue, to itchy rashes or hives, bronchospasm, respiratory failure, hypotension, and death as a result of acute anaphylaxis. In studies conducted in Italy in the Abruzzo region, approximately 6% of samples were found to be non-compliant with the histamine content requirements [100]. Commission Regulation (EC) No. 2073/2005 allows for a histamine content of 100 mg/kg in fish species. Fish species at increased risk of histidine occurrence include fish from the *Scombridae*, *Clupeidae*, *Engraulidae*, *Coryphenidae*, *Pomatomidae*, and *Scombresosidae* [101]. In similar studies conducted in Poland, histamine was detected in 14.1% of raw fish samples, 29% of smoked fish, 22% of canned fish, and 93.8% of marinated fish at concentrations ranging from 3.4 to 156.4 mg/kg. Contents of this amine above 100 mg/kg were found in four samples: raw Atlantic salmon,

smoked European sprat, and two samples of marinated Atlantic herring [102]. Studies on histamine content in fish and fish products show that special attention should be paid to the quality of the raw material, storage temperature, and hygienic practices when handling and processing fish and fish products. To counteract this, various innovative preservation and packaging technologies have emerged. Techniques such as high-pressure processing (HPP), modified atmosphere packaging (MAP), biopreservation, and active and vacuum packaging have shown the ability to extend the shelf life of seafood by up to 50% [103].

4.2.4. Falsification of Health Certificates

Health certificate fraud was also listed among the ten most frequently reported hazards notified in RASFF as border rejections between 2016 and 2017. Food fraud has long been recognised as a serious problem in the food industry and is associated with serious economic and public health issues. The RASFF database reported 1166 cases in the hazard category "Adulteration/fraud" between 2000 and 2020, of which 663 cases (56.9%) concerned food products from Asia. More than 70% of food adulteration and fraud originated from Asia and was detected in products from China (200), India (172), and Turkey (117). Nuts, nut products, and seeds were the most frequently reported food products with adulteration (189 cases), followed by fruits and vegetables (96 cases) and herbs and spices (89 cases). Within this category, health certificates were documented in only 440 cases. In 279 of the reported cases, health certificates were missing; in 99 cases, the health certificate was incorrect; in 52 cases, false health certificates were found; and in one case, the health certificate was invalid [104]. Owolabi and Olayinka (2021) [105] also investigated cases of adulteration and fraud in food imported to the European Union from the Association of Southeast Asian Nations (ASEAN) region. They found that among the 10 ASEAN member countries, the highest number of food fraud cases was found in food imported from Thailand (47 cases), followed by the Philippines (37 cases). A serious number of cases of food adulteration and fraud was also reported in herbs and spices imported from this region [105]. The export of adulterated herbs and spices without appropriate health certificates and full analytical reports is one of the main problems in ASEAN food exports to European countries.

4.2.5. Additives: Colours and Sulphites

The next hazards listed among the ten most frequently reported in the RASFF as border rejections were additives. In this group of compounds, the presence of prohibited dyes in cereals and bakery products and sulphites in fruits and vegetables were recorded. Dyes (colours) play an important role in the sensory marketing of food. The first contact of the customer with the product is visual; therefore, the colour of the packaging and the product must attract attention [106]. Food colours are associated with product properties such as taste, aroma, sensory values, and authenticity. However, synthetic food colours can cause a number of harmful effects on human health; therefore, most of them are not used or allowed in food production, and the origin of food colours is the subject of greater attention due to their safety [107]. Synthetic food colours are often considered an unnecessary risk to consumer health. Amchova et al. (2024) analysed dyes such as quinoline yellow, sunset yellow, azorubine, amaranth, ponceau 4R, erythrosine, allura red, patent blue, indigo carmine, brilliant blue FCF, green S, brilliant black, brown HT, and lithol ruby BK [108]. These dyes are of great health concern, with potential impacts on children's behaviour [109]. They belong to the azo group and are among the food additives that are widely used as food colorants. Azo dyes are added to food to impart colour, but they have no nutritional value, food preservation value, or health benefits. The safety of these dyes remains controversial, as studies have shown their negative effects on endocrine disruption,

phototoxicity, and histamine release, potentially causing various allergies and exacerbating asthma symptoms [110]. Tartrazine is also an azo dye that has previously raised serious concerns about consumer safety at low doses relevant to actual human exposure [111]. The European Union has introduced regulations on the use of food additives, including dyes, in Regulation (EC) No. 1333/2008 [112].

However, it must be remembered that not all food products can be coloured, because giving them colour is not permitted by legislative authorities. Examples of such food products include water, milk, chocolate, vegetables and fruits, oils, some fruit juices, and cheeses, flour and pasta, meat, fish, eggs, and others [113]. In recent years, changes have been taking place in food production and consumption. The involvement of various bodies in the promotion of sustainable agriculture and better use of food raw materials by reducing food waste, among others, is growing.

Besides colours, the presence of additives such as sulphites in food can also result in border rejections reported in the RASFF. The term "sulphites" refers to several inorganic chemical compounds such as sulphur dioxide, bisulphites, metabisulphites, and sulphur salts containing potassium, calcium, or sodium. Sulphites are used as a substance added to food to limit the growth of micro-organisms and prevent browning and spoilage of food. Due to their various properties, sulphites are commonly added to a wide range of food and beverages, including fruits and vegetables, seafood, juices, alcoholic and non-alcoholic beverages, meat, and cereals [114]. A list of all compounds classified as sulphites, along with their numbering, is included in the FAO/WHO Codex Alimentarius document: "Codex General Standard for Food Additives" [115]. In relation to meat products, different countries have raised concerns about the addition of sulphites. These compounds are especially added to ground beef to prevent browning. However, there are serious concerns that sulphites cause the meat to take on an unnatural colour and, in addition, the action of sulphur compounds leads to the degradation of nutrients of high nutritional value (especially vitamins) [116].

Sulphites are generally considered to be relatively safe at the doses used. However, several cases of moderate or severe skin and respiratory reactions, some of which were serious and even fatal, have been described in the medical literature [117]. Currently, the FAO/WHO lists sulphite compounds as allergens, but not all countries have included them on their allergen list. Another risk to human health is related to the effects of these compounds on microflora. Preservatives can change the gut and/or oral microbiome. Studies by Irwin et al. (2017) have shown that sulphites have a bactericidal effect on *Lactobacillus casei*, *Lactobacillus plantarum*, *Lactobacillus rhamnosus*, and *Streptococcus thermophilus* [118]. Recent studies indicate that sulphites can be replaced by many new natural preservatives and antioxidants, such as plant and fruit extracts and powders (green tea, rosemary, curry leaves, spinach, broccoli, pomegranate, beetroot), purified active molecules, proteins and peptides (polyphenols, chitosan, carvacrol, lysozyme), and essential oils. Research on this topic should be carried out to reduce the amounts of added sulphites [119].

4.2.6. Chromium

Other hazards that were reported in the RASFF as border rejections include chromium migration from food contact materials. Requirements for the migration of toxic metals have been established for cadmium and lead from glass and ceramic vessels [120]. However, permissible migration limits for chromium and other metals have not yet been specified in EU legislation. Demont et al. (2012) [121] conducted studies on the migration of elements from ceramic vessels intended for contact with food to determine the level of risk to human health. Studies confirmed that the migration of other elements, in addition to lead and cadmium, can also pose health risks. Factors such as the pH and temperature of the solution

used to rinse the elements significantly affect the migration of trace elements from ceramic products. The type of pigment used to decorate the glaze also plays a significant role [121]. In turn, Szynal et al. (2016) [122] conducted research on the migration of chromium and nickel from ceramic and glass vessels available on the Polish market intended for contact with food. As a result of these studies, no risk to human health was found in the scope of nickel and chromium migration [122].

4.3. Limitations of the Studies Carried Out

The main problem was the need to merge data from two RASFF databases, i.e., the restored (archived) one for 2008–2021 and the currently available one for 2022–2023. These data are structured differently, and additionally, the individual values of the variables under study may have been named differently and contained mistakes that required harmonisation and correction before the analysis could be carried out. In addition, as the open-access data previously included in the RASFF have been transferred to other systems due to the introduction of the Alert and Cooperation Network, many of them could not be taken into account in the analysis.

Due to Brexit, data on notifications reported by the United Kingdom are not included in the RASFF database from 2021 onwards. It is worth noting that this country has been very active in reporting border rejections, as can be seen from Table 2. Meanwhile, countries such as Norway and Switzerland, for example, are members of the system, even though they are not in the European Union. In turn, in the case of Eurostat, data (according to in the Standard International Trade Classification) for the United Kingdom are no longer available as of 2020. The lack of these data means that the numbers presented (in the case of RASFF) as well as the quantities (in the case of Eurostat) are underestimated. It is also worth noting that the different names of product categories in the RASFF and product divisions in Eurostat made them difficult to compare.

5. Conclusions

This study is a comprehensive approach to the issue of food rejections at the European Union border posted in the Rapid Alert System Form Food and Feed (RASFF) in 2008–2023, the period when they started to be recorded in the system. A research gap was identified, consisting of a few sudies and the fragmentary use of the RASFF notification database so far. The in-depth analysis carried out as part of this work used combined data from the archived and new RASFF databases. Eurostat and mining tools supported by VOSviewer allowed the authors of this study to obtain results not presented in other works so far.

Notifications relating to border rejections accounted for 38.7% of all notifications reported in the RASFF between 2008 and 2023. However, considering the quantity of imports and the hazards, the biggest concerns were for fruits and vegetables imported from Turkey by The Netherlands, Italy, France (presence of ochratoxin A), and Spain (sulphites). Despite importing less, it is also important to mention the pesticides and sulphites reported by Bulgaria in fruits and vegetables from Turkey. In turn, in nuts from Turkey, The Netherlands reported aflatoxins. The presence of *Salmonella* spp. in products from Brazil, i.e., poultry reported by The Netherlands and spices claimed by Germany, is also worth noting. In turn, Spain reported poor temperature control in fish from China and Morocco, and Poland reported moulds in feed and fruits and vegetables from Ukraine.

In order to ensure the safety of food and food raw materials at their source, it is necessary to extend authenticity and traceability measures in the planning and management of crops (and livestock), harvesting and storage, as well as processing and transport. Therefore, European Union authorities should expand their cooperation with food-exporting countries by providing training, taking into account local conditions related to the need

for Good Manufacturing Practice (GMP) and Good Hygienic Practice (GHP), joint on-site controls in production, processing and distribution, as well as assistance in shaping local food law.

However, in the context of food-related risks to life and health, the relevance of RASFF should be considered very substantial. Due to the common market and the free movement of products within it, rejections at the external border of the European Union appear to have a very significant impact on ensuring food safety for the European consumer. Importantly, they require responsibility and close cooperation between the authorities working at the border posts in the individual member states. Further research in this area could take into account not only the product categories reported in the RASFF but also individual products imported from different countries in connection with changes in the age structure of the population, dietary changes, migration, and tourism.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su17072923/s1, Figure S1: Results of the analysis of border rejections for aflatoxins reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S2: Results of the analysis of border rejections for pesticide(s) reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S3: Results of the analysis of border rejections for *Salmonella* spp. reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S4: Results of the analysis of border rejections for poor temperature control reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S5: Results of the analysis of border rejections for health certificate(s) reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S6: Results of the analysis of border rejections for colour reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S7: Results of the analysis of border rejections for chromium reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S8: Results of the analysis of border rejections for ochratoxin A reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S9: Results of the analysis of border rejections for mould(s) reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin; Figure S10: Results of the analysis of border rejections for sulphite(s) reported in the RASFF in 2008–2023; (a) Year; (b) Product category; (c) Notifying country; (d) Country of origin.

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Abbreviations

The following abbreviations are used in this manuscript:

AAC	Administrative Assistance and Cooperation Network
ACN	Alert and Cooperation Network

ADI	Acceptable Daily Intake
ARfD	Acute Reference Dose
ASEAN	Association of Southeast Asian Nations
Bw	Body Weight
CAP	Common Agricultural Policy
CCPR	Codex Committee on Pesticide Residues
EEA	European Economic Area
EFSA	European Food Safety Authority
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FFN	Agri-Food Fraud Network
GHP	Good Hygienic Practice
GMP	Good Manufacturing Practice
HPP	High-Pressure Processing
HRs	Highest Residues
IARC	International Agency for Research on Cancer
MAP	Modified Atmosphere Packaging
MRLs	Maximum Residue Limits, Maximum Residue Levels
NATO	North Atlantic Treaty Organization
OTA	Ochratoxin A
PHN	Plant Health Network
RASFF	Rapid Alert System for Food and Feed
SFSC	Short Food Supply Chains
SITC	Standard International Trade Classification
STMRs	Supervised Trials Median Residues
WHO	World Health Organization
WoS	Web of Science

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