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Hazards in Products from Northern Mediterranean Countries Reported in the Rapid Alert System for Food and Feed (RASFF) in 1997–2021 in the Context of Sustainability

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Abstract: The European Green Deal attaches great importance to sustainability, including food security, which is also linked to food safety. This is particularly relevant in such a sensitive region as the Mediterranean. The goal of this study was to investigate Rapid Alert System for Food and Feed (RASFF) notifications of hazards reported in 1997–2021 (a 25-year period) in products from northern Mediterranean countries considering products and other variables. A two-way joining cluster analysis was used. The most notable hazards in the latter years of the reported period were as follows: ochratoxin A and pesticide residues in fruits and vegetables imported from Turkey and ethylene oxide in various products, as well as *Salmonella* in chicken, *Listeria* in cheese, *Escherichia coli* in cheese and mussels from France, mercury in swordfish from Spain, and *Anisakis* in seafood from France and Morocco. The increasing number of notifications of ochratoxin A and pathogenic micro-organisms in recent years may be caused by climate change. This also results in the need to use more pesticides and the appearance of related hazards, i.e., residues of such compounds in food products. It is, therefore, vitally important that border posts and control authorities in particular European Union countries are vigilant.

Keywords: food safety; mycotoxins; pesticide residues; pathogenic micro-organisms; cluster analysis; European Union

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1. Introduction

The objectives of the European Union's (EU) Green Deal for agriculture are as follows: to ensure food security facing global uncertainties, climate change, and biodiversity damage; to diminish the environmental and climatic footprint of the European food system; to extend the resilience of this system; and, finally, to introduce a global transition into competitive sustainability from farm to fork [1].

The geographical location of countries is crucial to their development, not only culturally and socially, but also economically. The Mediterranean Sea is enclosed and only accessible through Gibraltar (Europe) and via the Suez Canal (Africa). It is at the confluence of three continents with different cultures: Europe, Africa, and Asia. The climate is characterized by warm and dry summers and mild winters. Most trade between countries along the coast is by the sea route. There is also a well-developed road network in the northern part of the Mediterranean region in the EU member states [2–4].

These determinants are beneficial to the trade of food and feed. Different products are grown in individual countries, which affects their imports and exports [5]. In addition, they may have varying agricultural regulations, for example, regarding the use of pesticides or product packaging materials. Furthermore, food safety law is much stricter in EU countries, which may influence how the imported product is treated once it reaches the border. This may cause obstacles to trade between EU and other countries [6]. The factors mentioned above are important because unsafe food products can cause many problems. Understanding them properly allows for better food safety policies to be created, which has the benefits of reducing the incidence of diseases, leading to a lower public health burden, minimizing financial losses throughout the food system, promoting increased consumption of nutritious food, and reducing the environmental consequences of avoidable food losses and wastage.

However, in order to carry out an analysis of the hazards present in food, it is necessary to have a historical dataset of the problems that have occurred in a particular area. The European Union has a mechanism for reporting hazards in food products reaching the common market or detected at its borders known as the Rapid Alert System for Food and Feed (RASFF).

1.1. Notifications for the Northern Mediterranean Region in the RASFF

The RASFF was established as early as 1979; however, it is now based on Regulation 178/2002, also known as the General Food Law. This system enables the exchange of information between member countries, i.e., mainly EU countries, to support the rapid reaction of market surveillance authorities in the case of public health risks resulting from the food chain [7].

The following countries can be considered as the northern part of the Mediterranean region: Albania, Bosnia and Herzegovina, Croatia, Cyprus, France, Greece, Italy, Malta, Monaco, Montenegro, San Marino, Slovenia, Spain, and Turkey. There is also a similar climate in coastal Morocco, but in the other countries of North Africa, a dry climate prevails.

Over the period 1997–2021, notifications for food originating from northern Mediterranean countries accounted for 24.3% of all the notifications in the RASFF, but in the earlier years, only a few to ten notifications per year were submitted. The number of notifications submitted in the RASFF in the analyzed period on products from the northern Mediterranean countries is shown in Table 1. The following variables were considered: the country of origin, product category, and hazard category. The notifications are ordered in descending numerical order.

In the mentioned period, notifications were mainly reported on products originating from Turkey (38.9%), Spain (18.4%), France (16.7%), and Italy (14.6%). Regarding the product categories, the following were primarily submitted: fruits and vegetables (31.0%), fish (12.9%), and nuts (11.3%). In turn, considering the hazard category, the most frequently reported were mycotoxins (19.8%), pesticide residues (19.0%), and pathogenic micro-organisms (14.8%), in total, representing 53.4% of all notifications. Figure 1 shows the number of notifications in the RASFF reported on products from northern Mediterranean countries per year over the period 1997–2021, taking into account these three hazard categories.

The growth in the number of notifications was initially slow until 2000, but, later, reached a faster pace. Between 2004 and 2016, this number remained in the range of 600–900 per year, then increased to about 1000, finally reaching an unprecedented 1700 notifications, mainly due to the rising number of notifications of pesticide residues.

Table 1. The number of notifications reported on products from the northern Mediterranean countries in the RASFF in 1997–2021.

Variable	Value—Number of Notifications (Percentage)
Country of origin	Turkey—6399 (38.9%), Spain—3038 (18.4%), France—2744 (16.7%), Italy—2397 (14.6%), Morocco—789 (4.8%), Greece—474 (2.9%), Croatia—209 (1.3%), Slovenia—134 (0.8%), Cyprus—93 (0.6%), Albania—72 (0.4%), Malta—58 (0.4%), Bosnia and Herzegovina—55 (0.3%), San Marino—4 (below 0.1%), Monaco—3 (below 0.1%), Montenegro—1 (below 0.1%)
Product category	Fruits and vegetables—5100 (31.0%); fish and fish products—2132 (12.9%); nuts, nut products, and seeds—1858 (11.3%); meat and meat products (other than poultry)—901 (5.5%); bivalve molluscs and products thereof—853 (5.2%); milk and milk products—723 (4.4%); herbs and spices—667 (4.0%); cereals and bakery products—623 (3.8%); poultry meat and poultry meat products—485 (2.9%); dietetic foods, food supplements, and fortified foods—404 (2.5%); other product categories—2724 (16.5%)
Hazard category	Mycotoxins—3225 (19.6%), pesticide residues—3124 (19.0%), pathogenic micro-organisms—2.441 (14.8%), heavy metals—1158 (7.0%), food additives and flavourings—910 (5.5%), microbial contaminants (other)—820 (5.0%), foreign bodies—675 (4.1%), composition—576 (3.5%), allergens—575 (3.5%), parasitic infestation—406 (2.5%), other hazard categories—2560 (15.5%)

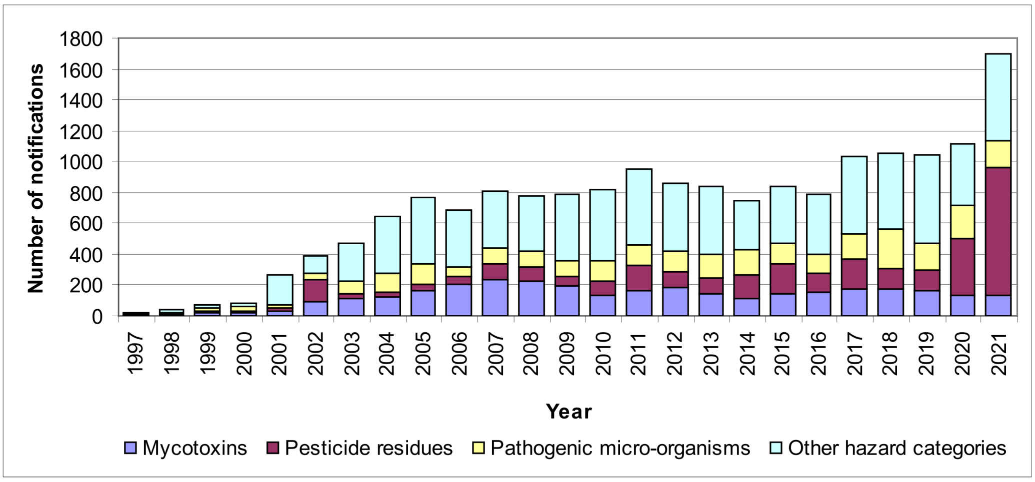

Figure 1. The number of notifications in the RASFF reported on products from Mediterranean countries per year over the period 1997–2021.

1.2. Goal of the Study

The main motivation for this work arose from the particular importance of the northern Mediterranean zone. Until recently, the Mediterranean climate was the most favourable for humans; therefore, it is important to carry out research into the safety of food originating from this region. However, this region is now experiencing significant climate change, such as high temperatures, droughts, and floods [8–10]. It should be considered that climate is a prime condition in food trading, with implications on how food products are grown, or which products need to be imported due to the lack of climatic conditions for their production [11]. Also, the cultural differences observed between these countries have implications on the consumption of food, e.g., pork is not consumed in Morocco. There is a particular lack of more detailed research, which could present an analysis of RASFF notifications on food from this area in a multidimensional way, allowing multiple variables to be analyzed simultaneously.

Therefore, the goal of this study was to investigate RASFF notifications of hazards reported in 1997–2021 (a 25-year period) in products from northern Mediterranean countries considering the year, hazard, product, country of origin, notifying country, notification type, notification basis, distribution status, and action taken as variables, using cluster analysis. The main novelty of this work lies in the use of advanced statistical methods and the subsequent analysis that is able to capture different features to those in the previous literature on this subject.

In relation to the goal of this study, the following research questions were formulated: (i) What is the scale and type of RASFF notifications on products from northern Mediterranean countries? (ii) In what type of food and what hazards are reported in the RASFF on these products? (iii) What type of hazards are reported in the RASFF on fruits and vegetables imported into the European Union from Turkey? And (iv) how do the authors of scientific papers relate food to the Mediterranean region?

2. Materials and Methods

The RASFF database, which is now officially available on the European Commission's website, only contains data from 2020 onwards. Earlier data are only available to the supervisory authorities of the member countries [12]. Therefore, the data were obtained from the archived European Commission website [13]. The data were output as Microsoft Excel 365 (Microsoft Corporation, Redmond, DC, USA) files and covered 10,070 notifications (more precisely, records) reported between 1997 and 2021 on food from northern Mediterranean countries. The data were organized according to the following variables: year, hazard, product, country of origin, notifying country, notification type, notification basis, distribution status, and action taken. This was performed using vertical searching, sorting, pivot tables, and transposition functions.

The following operations were carried out during the data pre-processing:

- Only notifications related to food were selected, so two other types of products, i.e., feed and food contact materials, were excluded from the study;
- The year of notification was obtained from the notification number (i.e., from the "Reference" cell in the database);
- The name of the product was obtained from the "Subject" cell in the database; these names were then also harmonized and corrected;
- The different entries for the names of the countries of origin and the notifying countries were harmonized and corrected;
- The very rarely used name of the hazard category "Metals" was changed to "Heavy metals";
- Notification types such as "Information for attention" and "Information for follow-up" (only introduced from 2011 onwards) were changed to "Information" to standardize the name of this type of notification throughout the study period;
- The names of some values of variables such as hazard category, product category, notification basis, distribution status, and action taken have been shortened in order to fit on the charts (legends are provided below the charts in the text or in the Supplementary Materials);
- Missing data were replaced with the phrase "(Not specified)" (this applied to the variables notification basis, distribution status, and action taken, mostly in the early years of the period studied).

In order to examine similarities within and between variables, a two-way joining cluster analysis in Statistica 13.3 (TIBCO Software Inc., Santa Clara, CA, USA) was performed. Cluster analysis means grouping objects based on their similarities so that, within clusters, the similarity of the objects is such that the particular clusters are sufficiently different from each other [14]. This type of analysis is used when it is assumed that values placed both in the rows (as cases) and in columns (as variables) of the source tables can lead to the uncovering of significant cluster patterns [15].

Two-way joining cluster analysis was used to pre-signpost the most frequently reported hazards, considering two relationships: hazard categories and countries of origin, and hazard categories and product categories. This analysis was also carried out for an in-depth detailed study on hazards for which there were more than 100 reported notifications. Thirty such hazards were identified and they accounted for 68.2% of all notifications reported on products from northern Mediterranean countries in the studied period [13]. For each of these hazards, years were placed in the rows of the source tables, while the names of the variables, i.e., product, country of origin, notifying country, notification type, notification basis, distribution status, and action taken, were included in the columns.

As a result of the two-way joining cluster analysis, the values in the rows and columns of the source table were reorganized so that the clusters were visible as blocks, with objects showing similar values [16]. The structure of this analysis is not homogeneous by nature; however, it is considered to offer a powerful tool for data exploration [15]. This type of analysis is useful for discovering patterns in large datasets [17]. In this study, the clusters were expressed by coloured squares, starting with green, followed by yellow, orange, and, finally, red and brown, indicating the largest clusters. The dark green colour was changed to white as it occupied the largest part of each chart and did not indicate the presence of significant clusters. The graphical results of this analysis as contour/discrete charts were presented in two-dimensional form. However, by overlaying the results of the analysis carried out for each hazard, it was possible to obtain a multidimensional picture, indicating not only similarities but also relationships.

In order to investigate the interrelation of words used by authors of scientific works on the Mediterranean and food, VOSviewer 1.6.20 (Centre for Science and Technology Studies, Leiden University, The Netherlands) was used. An exploration of the links between these keywords was carried out to put into a broader context the circumstances surrounding the hazards reported in the RASFF in food products from northern Mediterranean countries. First, the Web of Science (WoS) database was searched, using the phrase "Mediterranean* AND food", for scientific works from 1997 to 2023 (two years longer than the research period to also see the latest research trends in this field). It should be noted that the words mentioned may not even have been indicated directly by the authors in the keywords of the work. However, they could have occurred, for example, in the title, abstract or text, linking indirectly to the subject matter analyzed. Finally, 27,877 results were obtained with the data, which were then exported to text files [18]. These data were then analyzed in VOSviewer using the following options: type of analysis (co-occurrence), unit of analysis (author keywords), counting method (full counting), and minimum number of occurrences of the keyword (90). The minimum number of occurrences was increased progressively until the optimum arrangement of elements and readability of the visualizations (network and overlay) was achieved.

3. Results

3.1. Most Frequently Reported Hazards

The findings of the two-way joining cluster analysis including the hazard categories and countries of origin are shown in Figure 2, and the hazard categories and product categories are shown in Figure 3.

Considering the countries of origin, the most visible risks were mycotoxins (brown colour) and pesticide residues (red colour) in products from Turkey (Figure 2). In turn, considering the product categories, it is important to note the presence of mycotoxins in fruits and vegetables and nuts and seeds (orange colour), and pesticide residues in fruits and vegetables (brown colour) (Figure 3). In both Figures 2 and 3, it can also be seen that pathogenic micro-organisms were also notified (green colour). These are the most pronounced of the problems reported. Much more detailed results are presented in Section 3.2.

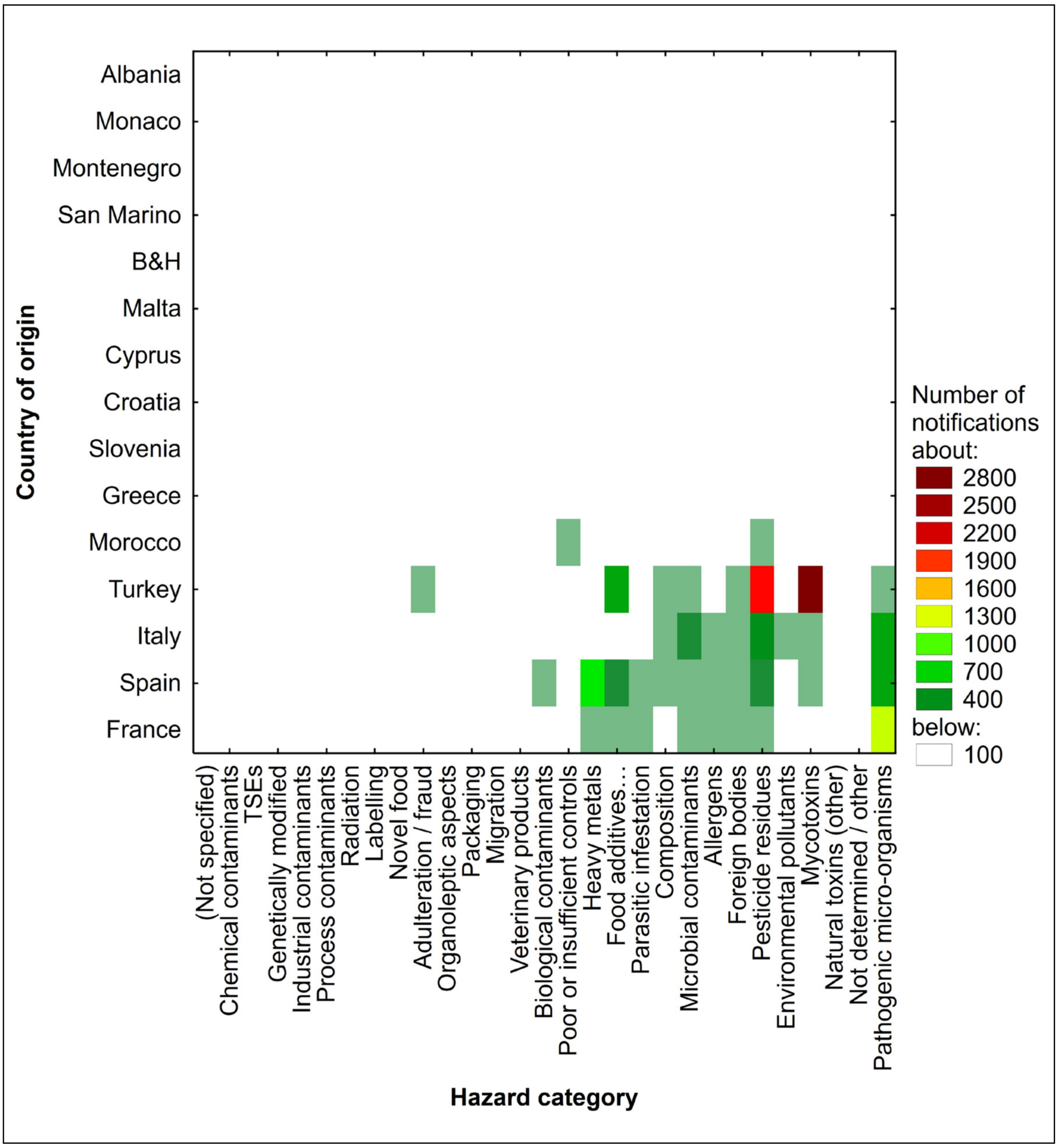

Figure 2. The findings of cluster analysis for hazard categories and countries of origin on products from northern Mediterranean countries reported in the RASFF in 1997–2021. Explanations for hazard categories: biological contaminants—biological contaminants (other); chemical contaminants—chemical contaminants (other); food additives…—food additives and flavourings; genetically modified—genetically modified food or feed; labelling—labelling absent/incomplete/incorrect; microbial contaminants (other)— microbial contaminants (other); packaging—packaging defective/incorrect; veterinary products—residues of veterinary medicinal products; TSEs—transmissible spongiform encephalopathies. Explanations for countries of origin: B&H—Bosnia and Herzegovina.

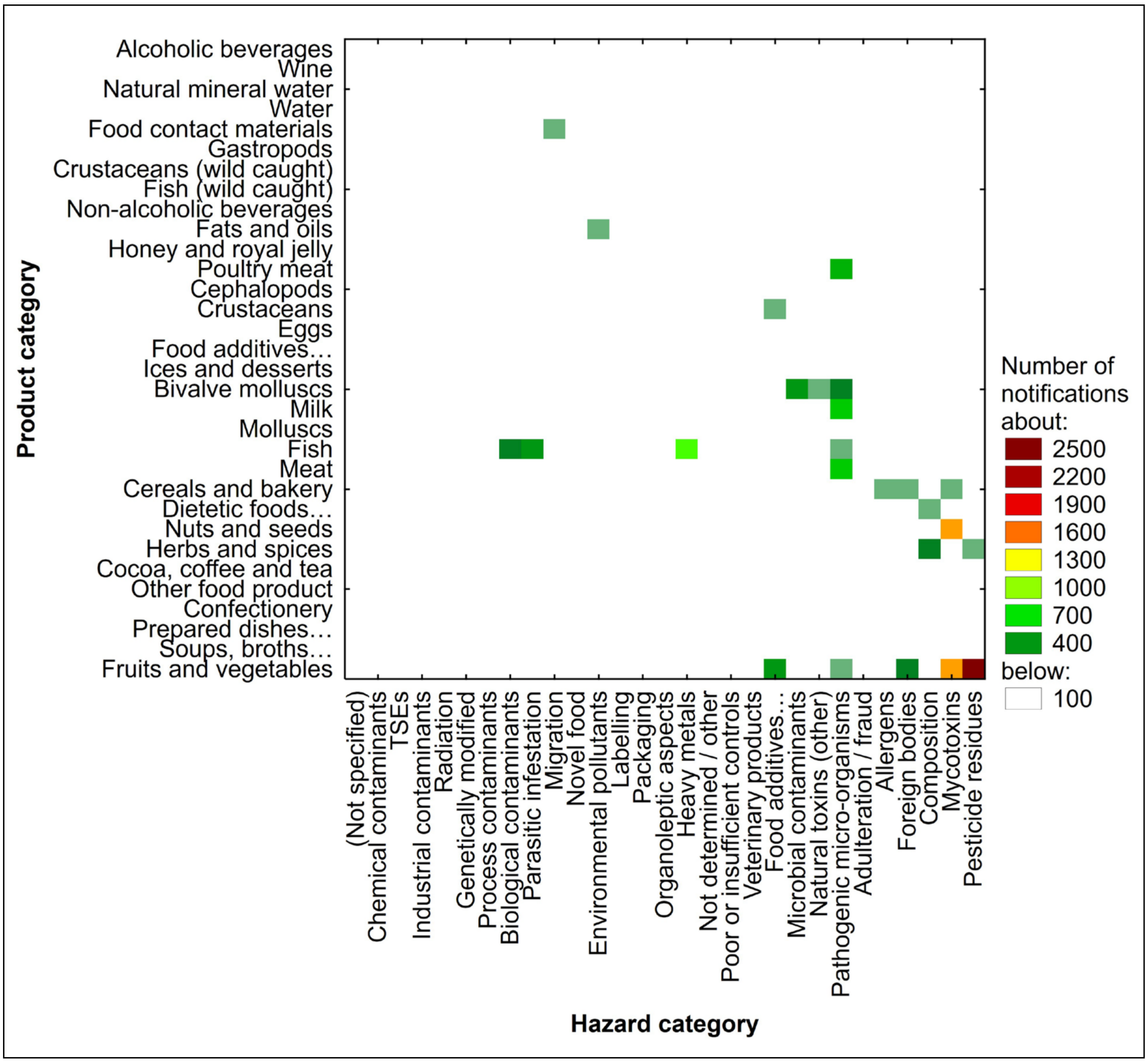

Figure 3. The findings of cluster analysis for hazard categories and product categories on products from northern Mediterranean countries reported in the RASFF in 1997–2021. Explanations for hazard categories: biological contaminants—biological contaminants (other); chemical contaminants—chemical contaminants (other); food additives. . .—food additives and flavourings; genetically modified—genetically modified food or feed; labelling—labelling absent/incomplete/incorrect; microbial contaminants (other)— microbial contaminants (other); packaging—packaging defective/incorrect; veterinary products—residues of veterinary medicinal products; TSEs—transmissible spongiform encephalopathies. Explanations for product categories: bivalve molluscs—bivalve molluscs and products thereof; cephalopods—cephalopods and products thereof; cereals and bakery—cereals and bakery products; cocoa, coffee and tea—cocoa and cocoa preparations, coffee, and tea; crustaceans—crustaceans and products thereof; dietetic foods. . .—dietetic foods, food supplements, and fortified foods; eggs—eggs and egg products; fish—fish and fish products; food additives. . .—food additives and flavourings; meat—meat and meat products (other than poultry); milk—milk and milk products; molluscs—molluscs and products thereof; nuts and seeds—nuts, nut products, and seeds; poultry meat—poultry meat and poultry meat products; soups, broths. . .—soups, broths, sauces, and condiments; water—water for human consumption (other); crustaceans (wild-caught)—wild-caught crustaceans and products thereof; fish (wild caught)—wild-caught fish and products thereof (other than crustaceans and molluscs).

3.2. Detailed Results for Particular Hazards

Table 2 shows the hazards reported in the RASFF in the period 1997–2021 on products from northern Mediterranean countries with more than 100 notifications (by number of notifications with minor exceptions). They have been ordered in descending order of number of particular hazard category or categories.

Table 2. Hazards above 100 notifications on products from the northern Mediterranean countries reported in the RASFF in the period 1997–2021.

Hazard (Specific Hazard—Number)	Number	Percentage	Hazard Category or Categories—Number
Aflatoxins	2797	17.0%	Mycotoxins
Ochratoxin A	326	2.0%	
Chlorpyrifos	292	1.8%	Pesticide residues
Ethylene oxide	213	1.3%	
Formetanate	208	1.3%	
Chlorpyrifos-methyl	194	1.2%	
Acetamiprid	142	0.9%	
Oxamyl	113	0.7%	
Prochloraz	100	0.6%	
Salmonella (*Salmonella enterica*—645)	1181	7.2%	Pathogenic micro-organisms—1180, (Not specified)—1
Listeria (*Listeria monocytogenes*—692)	708	4.3%	Pathogenic micro-organisms—693, Microbial contaminants (other)—15
Escherichia coli	580	3.5%	Microbial contaminants (other)—454, Pathogenic micro-organisms—126
Campylobacter (*Campylobacter jejuni*—33, *Campylobacter coli*—17)	103	0.6%	Pathogenic micro-organisms
Norovirus	196	1.2%	Pathogenic micro-organisms
Moulds	150	0.9%	Microbial contaminants (other)
Histamine	269	1.6%	Biological contaminants (other)
Mercury	846	5.1%	Heavy metals
Cadmium	194	1.2%	
Sulphite	655	4.0%	Food additives and flavourings—549, Allergens—106
Colour	178	1.1%	Food additives and flavourings—175, Composition—2, Migration—1
Milk	116	0.7%	Allergens
Sudan (Sudan 1—209, Sudan 4—81)	294	1.8%	Composition
Anisakis	349	2.1%	Parasitic infestation
Insects	198	1.2%	Foreign bodies
Glass	158	1.0%	
Foodborne outbreak	155	0.9%	Not determined/other
Health certificate(s)	147	0.9%	Adulteration/fraud
Diarrhoeic shellfish poisoning (DSP) toxins	131	0.8%	Natural toxins (other)
Benzo(a)pyrene	126	0.8%	Environmental pollutants
Poor temperature control	119	0.7%	Poor or insufficient controls
All the above 30 hazards	11,238	68.2%	
Other hazards	5232	31.8%	
Total	16,470	100.0%	

The 30 aforementioned hazards were subjected to a more detailed two-way cluster analysis, with the Y axis showing the particular years from 1997 to 2021 and the X axis showing the names of the individual variables (Figures S1–S30 in Supplementary Materials). Subsummaries of the results of the cluster analysis for the particular hazard categories are available in the Supplementary Materials in Tables S1–S8 and are presented in the following subsections.

3.2.1. Mycotoxins (Aflatoxins and Ochratoxin A)

The findings of the analysis concerning mycotoxins are outlined in Figure S1 (aflatoxins) and Figure S2 (ochratoxin A) and gathered in Table S1.

Aflatoxins were notified in figs in 2006–2012 and in hazelnuts in 2006–2009. They were submitted by Germany (in 2006–2012), Italy (in 2007), and France (in 2008–2009 and 2012). The reported products originated from Turkey, and these were information notifications and border rejections. Ochratoxin A was submitted by Germany and Poland in apricots, figs, and peppers in 2018 and by France in raisins in 2019. These products also originated from Turkey and were notified as border rejections.

Both aflatoxins and ochratoxin A were reported based on border controls, after which the food was detained. Consequently, the products were not distributed or placed on the market and were re-dispatched.

3.2.2. Pesticide Residues (Chlorpyrifos, Ethylene Oxide, Formetanate, Chlorpyrifos-Methyl, Acetamiprid, Oxamyl, and Prochloraz)

The results of the analysis concerning pesticide residues are shown in Figure S3 (chlorpyrifos), Figure S4 (ethylene oxide), Figure S5 (formetanate), Figure S6 (chlorpyrifos-methyl), Figure S7 (acetamiprid), Figure S8 (oxamyl), and Figure S9 (prochloraz) and are collected in Table S2.

Pesticide residues were reported most frequently by Bulgaria in fruits and vegetables originating from Turkey and these notifications concerned mainly recent years, as follows:

- Chlorpyrifos in peppers (2016–2021), snails (2018), and mandarins and oranges (2021);
- Formetanate in peppers (2011–2021);
- Chlorpyrifos-methyl in lemons and peppers (2020–2021) and grapefruits and mandarins (2021);
- Acetamiprid in peppers (2020–2021);
- Oxamyl in peppers (2007, 2010–2011);
- Prochloraz in mandarins and peppers (2020–2021) and lemons (2021).

The reported products were mostly notified based on border controls, after which the food was detained. In rarer cases, information notifications were also sent after official controls on the market. Products were not distributed or placed on the market. Various actions were taken against them, but the most common were destruction and re-dispatchment.

Ethylene oxide was notified in sesame seeds in 2020–2021. It was also found in additives, ice creams, and supplements in 2021 and these notifications related to products from France. The alerts were reported by Spain in 2020–2021 and by Belgium and France in 2021. The notification basis was the company's own check and submitted products could be distributed to other countries. They were recalled from the consumers or withdrawn from the market.

3.2.3. Pathogenic Micro-Organisms and Microbial and Biological Contaminants (*Salmonella*, *Listeria*, *Escherichia coli*, *Campylobacter*, Norovirus, Moulds, and Histamine)

The findings regarding the analysis of pathogenic micro-organisms and microbial and biological contaminants are shown in Figure S10 (*Salmonella*), Figure S11 (*Listeria*), Figure S12 (*Escherichia coli*), Figure S13 (*Campylobacter*), Figure S14 (norovirus), Figure S15 (moulds), and Figure S16 (histamine) and gathered in Table S3.

Salmonella was reported in duck (in 2004), pork (in 2004–2005 and 2018), turkey (in 2014 and 2019–2020), and chicken (in 2017–2021). *Salmonella enterica* was directly indicated in more than half of the cases. The notified products were submitted as alerts by Norway, Italy, and France. Notifications on *Listeria* (mainly *Listeria monocytogenes*) were made in 2003–2005 and 2010–2021 on cheese from France and were reported by this country as alerts.

Escherichia coli was found in clams (in 2010 and 2013–2014), mussels (in 2013, 2016–2019, and 2021), and cheese (in 2014 and 2018–2019). These products originated from Italy, Spain, and France and were submitted by Italy and Spain as alerts or information notifications. The notification basis was usually official controls on the market and the company's own checks. Products could be distributed to other countries and, eventually, they were returned to the consignor and recalled or withdrawn. In turn, *Campylobacter* (in a third of cases, it was *Campylobacter jejuni*) was notified in 2007 and 2018 by Denmark in chicken from France. These were information notifications reported based on official controls on the market, after which the products were recalled or withdrawn.

Besides bacteria, norovirus, moulds, and histamine were also submitted. Norovirus was reported in 2018 and 2020 by Italy in oysters from France. These were alerts and information notifications made based on official controls on the market, resulting in an official detention or withdrawal from the market.

Moulds were submitted in figs (in 2006), cheese (in 2006 and 2021), raisins (in 2009 and 2012–2013), hazelnuts (in 2012), and olives (in 2021). The majority of these products originated from Turkey, but also from Italy and were notified by Poland, the United Kingdom, and Germany. They were submitted within border rejections and information notifications. The notification basis was border controls, after which the food was detained, but also the company's own checks, consumer complaints, and official controls on the market. The notified products were mostly not distributed; however, distribution to other countries was possible. They were re-dispatched, withdrawn from the market, or recalled from consumers.

Notifications of histamine were reported by Italy in 2011–2012 in sardines from Morocco and in 2013, 2015, and 2017 in tuna from Spain. The notification basis was border control, after which the food was detained, or the company's own checks, food poisoning, and official controls on the market under information notifications. Products were destroyed, withdrawn from the market, or recalled from consumers.

3.2.4. Heavy Metals (Mercury and Cadmium)

The results of the analysis related to heavy metals are outlined in Figure S17 (mercury) and Figure S18 (cadmium) and summarized in Table S4.

Mercury was notified by Italy in swordfish (in 2007, 2010–2011, and 2013–2019) and in shark (in 2014 and 2017) from Spain. Cadmium was also reported in 2007–2009 in crabs from France by Italy. In the case of mercury, there were both alerts and information notifications, while, concerning cadmium, there were information notifications. The distribution of the reported products on the market was possible; however, in the case of mercury, the distribution status could also be more diverse. For both heavy metals, products were withdrawn from the market or destroyed; in the case of mercury, they were also seized or detained, and, regarding cadmium, they were also re-dispatched.

3.2.5. Food Additives and Flavourings, Allergens, and Composition (Sulphite, Colour, Milk, and Sudan)

The outcomes regarding the analysis of food additives and flavourings, allergens, and composition are shown in Figure S19 (sulphite), Figure S20 (colour), Figure S21 (milk), and Figure S22 (Sudan) and gathered in Table S5.

Sulphite was notified in two hazard categories, i.e., food additives and flavourings and allergens. It was reported in apricots (in 2003 and 2005) and figs (in 2017) from Turkey and in prawns (in 2004–2005) from France. Notifications were submitted by Spain and Italy. These were information notifications or border rejections. The notifications basis was border controls, after which the food was detained, or official controls on the market. The distribution was not specified or the products were not placed on the market. They were re-dispatched, recalled, or withdrawn, or import was not authorized.

Colour was reported within the hazard category "food additives and flavourings". It was submitted in chickpeas from Turkey (in 2004 and 2006) and in peppers from Spain (in 2018). The notified products were reported by Italy and Spain. These were information notifications made on the basis of border controls or official controls on the market. The distribution status of these products was not specified. However, they could also have been not distributed, or their distribution was restricted. They were re-dispatched or withdrawn from recipients.

Milk (as an allergen) was found in chocolate from Cyprus in 2007 and the RASFF was notified by this country. It was also reported by Spain in a supplement from France in 2009. These were information or alert notifications made after official controls on the market. The distribution of the submitted products was possible and they were recalled from consumers or withdrawn from the market.

Sudan (mainly Sudan 1) was reported within the hazard category "composition". It was submitted in sauce and chilli from Italy (in 2003), as well as pasta and peppers from Italy, France, and Turkey (in 2004). The notifications were made by Italy and Germany as alerts and provided after official controls on the market. The products were recalled or withdrawn.

3.2.6. Parasitic Infestation (*Anisakis*)

The results of the analysis relating to *Anisakis* are given in Figure S23 and collected in Table S6. This parasite was notified of in 2009–2011, 2017–2019, and 2021. It was found by Italy and Spain in hake, mackerel, anchovies, monkfish, and scabbardfish. These products originated from France, Spain, and Morocco and were notified because of official controls on the market or border control, after which the food was detained.

The notification type could be alert or information notifications, as well as border rejections. Products were destroyed, withdrawn from the market, or detained.

3.2.7. Foreign Bodies (Insects and Glass)

The outcomes of the analysis concerning foreign bodies are shown in Figure S24 (insects) and Figure S25 (glass) and gathered in Table S7.

Insects were reported in figs mainly from Turkey (in 2006–2008 and 2011–2012) and in chocolate from Italy (in 2011). These were primarily information notifications made by Eastern EU countries. The notification bases were consumer complaints, official controls on the market, and the company's own checks. Distribution to other countries was possible or information about it was not available. Products were re-dispatched, withdrawn from the market, or destroyed.

Notifications of glass were submitted in mustard (in 2006), chocolate (in 2011), olives (in 2017 and 2021), tomatoes (in 2016, 2019, and 2021) and risotto (in 2018). The origin countries of these products were France, Spain, and Italy and they were reported by France, Germany, Sweden, Italy, and the Netherlands as alerts. The notification bases were the company's own checks and consumer complaints. Distribution to other countries was possible and the notified products were recalled from consumers or withdrawn from the market.

3.2.8. Other Hazards Above 100 Notifications

The results of the analysis of the remaining hazards for which more than 100 notifications have been made are presented in Figure S26 (foodborne outbreak), Figure S27 (health certificate(s)), Figure S28 (diarrhoeic shellfish poisoning (DSP) toxins), Figure S29 (benzo(a)pyrene), and Figure S30 (poor temperature control) and summarized in Table S8.

The notification basis for foodborne outbreaks was food poisoning, which was reported in 2017 by Italy for tuna from Spain and in 2018–2020 by France for oysters from this country. These were information or alert notifications resulting in recalls from consumers or withdrawals from the market, whereby products were usually no longer available on the market.

Problems with health certificates were submitted by France and the United Kingdom in 2011–2012 and 2016 for figs, hazelnuts, chocolate, confectionery, peppers, and pistachios originating from Turkey. These were border rejections made after border controls. Food was detained and then re-dispatched, destroyed, or import was not authorized. As a result, the products were not distributed.

Diarrhoeic shellfish poisoning (DSP) toxins were reported by Italy. These notifications concerned molluscs from Greece (in 2001) and mussels from Italy (in 2010) and Spain (in 2013–2014 and 2021). Most of these were alerts, as well as information notifications, provided based on official controls on the market and leading to product withdrawal. The distribution status was diverse.

Benzo(a)pyrene was notified in 2001 by Germany, Norway, and Sweden in olive oil from Italy within alert notifications. This product was recalled or withdrawn.

Problems with poor temperature control related to fish, squids, sardines, lobsters, and octopus from Morocco were reported by Spain in 2011–2012, 2019, and 2021. The notification basis was border control, after which the food was detained, resulting in border rejections. The products were re-dispatched, or import was not authorized, whereby they were not distributed.

4. Discussion

Table 3 shows the notifications on products from northern Mediterranean countries in the top 10 for number of notifications in the RASFF annual reports for 2010–2021 (in the earlier years, such summaries were not provided).

Table 3. Notifications on products from the northern Mediterranean countries in the top 10 for number of notifications in RASFF annual reports for 2010–2021.

Reference	Country of Origin	Product Category/Categories	Hazard	Year
[19]	Turkey Spain	Fruits and vegetables; nuts, nut products, and seeds Fish and fish products	Aflatoxins Mercury	2010
[20]	Turkey	Fruits and vegetables; nuts, nut products, and seeds	Aflatoxins	2011
[21]	Turkey	Fruits and vegetables	Aflatoxins	2012
[22]	Turkey Spain Spain	Fruits and vegetables; nuts, nut products, and seeds Fish and fish products Fish and fish products	Aflatoxins Carbon monoxide Mercury	2013
[23]	Turkey Spain	Fruits and vegetables; nuts, nut products, and seeds Fish and fish products	Aflatoxins Mercury	2014
[24]	Turkey Spain	Fruits and vegetables; nuts, nut products, and seeds Fish and fish products	Aflatoxins Mercury	2015
[25]	Turkey Spain Turkey	Fruits and vegetables; nuts, nut products, and seeds Fish and fish products Fruits and vegetables	Aflatoxins Mercury Pesticide residues *	2016
[26]	Turkey Italy Spain Turkey	Fruits and vegetables; nuts, nut products, and seeds Eggs and egg products Fish and fish products Fruits and vegetables	Aflatoxins Fipronil Mercury Pesticide residues *	2017
[27]	Turkey Spain France Turkey	Nuts, nut products, and seeds Fish and fish products Bivalve molluscs and products thereof Fruits and vegetables	Aflatoxins Mercury Norovirus Ochratoxin A	2018
[28]	Turkey Turkey Spain	Fruits and vegetables; nuts, nut products, and seeds Fruits and vegetables Fish and fish products	Aflatoxins Ochratoxin A Mercury	2019
[29]	Turkey France Turkey	Fruits and vegetables; nuts, nut products, and seeds Bivalve molluscs and products thereof Fruits and vegetables	Aflatoxins Norovirus Pesticide residues *	2020
[30]	Turkey Turkey	Fruits and vegetables; nuts, nut products, and seeds Fruits and vegetables	Aflatoxins Pesticide residues *	2021

* Substance was not indicated.

In each of the RASFF annual reports for 2010–2021, northern Mediterranean countries appeared among the top 10 for the number of notifications, sometimes being indicated even 4–5 times. Particularly noteworthy is the fact that in almost every year, aflatoxins were reported in fruits and vegetables, as well as in nuts, nut products, and seeds from Turkey. Meanwhile, the analysis carried out did not show such a concentration of clusters for this hazard. It should be noted, however, that in the annual reports, the hazards were related to the entire product category, while in the conducted cluster analysis, they were referred to as specific products. Thus, the clusters resulting from the analysis were more dispersed. In turn, the data on ochratoxin A and pesticide residues in fruits and vegetables from Turkey, mercury in fish (swordfish) from Spain, and norovirus in bivalve molluscs (oysters) from France are consistent with the findings of the cluster analysis.

During the entire studied period, more than 50% of all the notifications on products from northern Mediterranean countries concerned hazards reported under three categories, i.e., mycotoxins, pesticide residues, and pathogenic micro-organisms.

As mentioned before, pesticides are mainly applied to fruits and vegetables farmed in Turkey (subsection "Mycotoxins (aflatoxins and ochratoxin A)"). They may be used to control mycotoxins and pathogenic micro-organisms in fruits and vegetables, as well as nuts. As mycotoxins are usually found in fruits and nuts [31], the use of pesticides in their case is common [32]. Pathogenic micro-organisms, on the other hand, are found not only in fruits and vegetables, but also in meat and dairy products [33]. Toptanci et al., (2021) [34] and Sancar et al., (2022) [35] also addressed the problem of pesticides in fruits and vegetables from Turkey, pointing out that they pose a risk to human health, and proposed increased control over their use and education of agricultural workers.

4.1. Determinants Related to Particular Hazards

4.1.1. Mycotoxins

At a global level, climate change will have meaningful impact on plant biogeography and fungal populations, which will influence the mycotoxin profile, as confirmed by predictive approaches and field studies. As a result of climate change, the number of aflatoxins B1 in Europe is expected to increase [36].

According to the opinion of the EFSA Expert Panel (CONTAM), aflatoxins are among the most dangerous toxins. In an extensive study, experts presented their scientific opinion on the hazards to human health related to the presence of aflatoxins in food. They assessed the toxicity of aflatoxins to humans, estimated the exposure of the European Union population to aflatoxins in the diet, and considered the risks to human health. The risk assessment included aflatoxin B1 (AFB1), aflatoxin B2 (AFB2), aflatoxin G1 (AFG1), aflatoxin G2 (AFG2), and aflatoxin M1 (AFM1). Typically, the aflatoxin risk refers to the sum of AFB1, AFB2, AFG1, and AFG2 [37].

Daou et al., (2022) [38] point out that due to climate change, global warming, the higher accumulation of carbon dioxide in the atmosphere, increased rainfall, the domination of extreme weather conditions such as heat and cold waves, and an increase in the incidence of floods and droughts may result in decreased plant and crop resistance, resulting in the deterioration of crop quality. All these factors will, in turn, impact food safety as fungal attack and mycotoxin-producing properties are expected to change. Such regions include the Mediterranean, which is heavily affected by ongoing climate change. Changes taking place in the Mediterranean include a growth in the frequency and intensity of droughts, a decrease in rainfall in the eastern Mediterranean, and a simultaneous increase in temperature by 2–3 °C. The number of hot days with temperatures above 30 °C is also likely to increase in many countries, including Spain, Morocco, Algeria, central Italy, the Balkans, and central Turkey.

The notifications of hazards related to aflatoxins often concerned dried fruits and nuts from Turkey (subsection "Mycotoxins (aflatoxins and ochratoxin A)" and Table 3). In Turkey, dramatic differences in climatic conditions between regions facilitated the spread of various foodborne mycotoxins. The levels of mycotoxins permitted in the European Union were exceeded in apple juice (35%), milk (21%), dairy products (12%), dried fruits and vegetables (11%), herbs (10%), cereals and cereal products (2%), nuts (1%), and feed (1%). This indicates an urgent need for additional research on the occurrence of mycotoxins in all types of food and feed originating from Turkey [39].

Bircan (2009) [40] showed the occurrence of ochratoxin A in dried fruits, particularly figs, apricots, and sultanas from Turkey. The problem of mycotoxin contamination of figs from Turkey was also noted by Kabak (2016) [41]. In turn, Tosun and Ozden (2016) [42] found high concentrations of ochratoxin A in red pepper flakes, the origin of which is related to drying methods and storage conditions, hygienic aspects, and safe packaging. Both Bircan (2009) [40] and Kabak (2016) [41] noted that although climatic conditions in Turkey are suitable for the occurrence of mycotoxins, the problems of controlling this hazard both during and after harvest need to be addressed.

4.1.2. Pesticide Residues

Pesticides are chemicals that are used in agriculture to protect plants from pests and to combat diseases. The use of pesticides increases crop yields and is economically important for agricultural producers. However, pesticides are not harmless and pose a threat to the natural environment, people, and animals [43]. Pesticides are believed to cause several diseases, including cancer and neurodegenerative diseases, are responsible for oxidative stress, and can damage DNA [44,45]. It should be noted that people most exposed to pesticides are farmers who have direct contact with these compounds during spraying and other activities [46].

The maximum residue levels (MRLs) of pesticide residues in food and feed are set in the EU by Regulation 396/2005, which has been in force since September 1, 2008. Information on pesticide residues in agricultural products is published by the European Food Safety Authority (EFSA) in annual reports. The report published in 2021 shows that of the total 87,863 samples analyzed, 96.1% fell below the MRL, while 3.9% exceeded this level, of which 2.5% were non-compliant [47].

In 2017–2021, notifications of exceeded pesticide residues in fruits and vegetables in the RASFF database were often reported in products originating from Turkey (subsection "Pesticide residues (chlorpyrifos, ethylene oxide, formetanate, chlorpyrifos-methyl, acetamiprid, oxamyl and prochloraz)" and Table 3). Research conducted in this country by Soydan et al., (2021) [48] shows that out of 3044 samples of fruits and vegetables, 11.6% exceeded the MRL and as many as 64 different pesticides were detected. Grapes had the maximum number of residues, followed by strawberries, dried apricots, dried figs, peaches, pomegranates, cherries, peppers, tomatoes, pears, nectarines, quinces, olives, fresh apricots, apples, and mandarins. Among the pesticides, the most frequently detected substance was azoxystrobin, a very popular fungicide. According to the authors, the area and number of monitored facilities should be increased to improve consumer safety. However, the most important action for a lasting improvement would be to strengthen farmers' education and knowledge transfer, as well as encourage producers to implement good agricultural practices and integrated pesticide management. The results also call for improvements in pesticide use practices [48].

In turn, fipronil was detected in eggs from chickens in Italy. This chemical insecticide is used on bird farms to protect against insects, including ticks, fleas, and mites. Fipronil has hepatotoxic, nephrotoxic, and neurotoxic effects and disrupts reproductive development and the endocrine system in humans and animals [49]. In Regulation 396/2005, the EU established MRLs for this substance in food of plant and animal origin intended for human consumption. Successive Regulations 1127/2014 and 1792/2019 amending Annexes II and III to Regulation 396/2005 set the MRL for fipronil, expressed as the sum of fipronil and its most toxic metabolite fipronil-sulfone, in eggs and meat not exceeding 0.005 mg kg^{-1}. Monitoring by the European Commission shows that the presence of fipronil was detected in eggs and poultry meat, and samples exceeding the MRL were reported by nine Member States: the Netherlands, Italy, Germany, Poland, Hungary, France, Slovenia, and Greece. This resulted in a recommendation to include fipronil and other acaricides in future monitoring activities of Member States [50]. Poultry farmers in Italy defend themselves against the accusation of using large doses of fipronil, claiming that industrial farms are under strict legislative control, and the presence of fipronil occurs in ornamental poultry raised on individual farms [51,52].

4.1.3. Pathogenic Micro-Organisms

Climate change is contributing to the faster transmission and expansion of the geographic range of diseases. Extreme rainfall has resulted in waterborne epidemics, and longer summer seasons have contributed to an increase in foodborne illnesses [53]. Pathogens mainly attack food stored in a humid environment, at high temperatures, and with a higher water content [54]. Under these conditions, seafood is more susceptible to contamination. It can become contaminated with pathogens at any stage, from harvesting to consumption. Sometimes, fish can become poisonous even in water due to some bacteria and algal toxins [55,56]. The problem of ensuring access to clean water without pathogenic organisms intended for drinking and food processing has recently become a major challenge [57].

Climate change is also increasing the incidence and severity of plant disease outbreaks, posing significant and growing risks to primary productivity, global food security, and biodiversity damage in many sensitive areas of the world. Furthermore, outbreaks pose an increased risk of developing plant diseases, threatening global food supplies, and decreasing natural plant biodiversity. The spread of climate change-related pathogens is considered one of the major threats to global forest health. Climate change may also result in a shift in the range of pathogens and hosts, increasing the spread of plant diseases to new areas. Additionally, transport and online trade contribute to the spread of pathogenic organisms [58].

The presence of pathogenic micro-organisms in food and nutrition is a big problem from the point of view of public health, because large-scale epidemic events may occur. Pathogenic micro-organisms are responsible for food poisoning and can be a serious health, social, and economic problem. Pathogenic biological agents in food include viruses, bacteria, and parasites that can cause foodborne infections. The most common pathogenic bacteria found in food include *Bacillus cereus*, *Campylobacter jejuni*, *Clostridium botulinum*, *Clostridium perfringens*, *Cronobacter sakazakii*, *Esherichia coli*, *Listeria monocytogenes*, *Salmonella* spp., *Shigella* spp., *Staphylococccus aureus*, *Vibrio* spp., and *Yersinia enterocolitica*. Dangerous viruses include hepatitis A and noroviruses. The parasites of note include *Cyclospora cayetanensis*, *Toxoplasma gondii*, and *Trichinella spiralis* [59].

The occurrence of *Salmonella* spp. in turkey from France was noted by Sévellec et al., (2019) [60]. Antunes et al., (2016) [61] detected this micro-organism in poultry from France, Italy, and Spain. In turn, Gonçalves-Tenório (2022) [62] noted *Salmonella* spp. in chicken from Turkey and *Campylobacter* spp. in poultry from Italy. Thépault et al., (2018) [63] indicated the presence of *Campylobacter* in chicken from France, recommending proper processing and hygiene practices. Martinez-Rios and Dalgaard (2018) [64] highlighted the prevalence of *Listeria monocytogens* in cheeses from Italy and Greece. In turn, Bellio et al.,

(2018) [65] and Condoleo et al., (2022) [66] focused on the occurrence of *Escherichia coli* in cheeses from Italy. Campos et al., (2022) [67] indicated these bacteria in mussels originating from Spain. Fouillet et al., (2020) [68] recorded outbreaks of gastroenteritis associated with the consumption of French oysters with norovirus, the origin of which has been linked to significant rainfall preceding fishing. The presence of mould in Turkish products has been reported by Ozturkogu-Budak (2016) [69] in milk foods, nuts, and fruit. Therefore, it is important to take measures to prevent fecal contamination of water and improve production and storage conditions for food materials.

Finally, the hazard of histamine in sardines from Morocco and tuna from Spain is addressed in the works of El Hariri et al., (2018) [70] and Altafini et al., (2022) [71]. This problem appears to be caused by the exposure of canned products to high temperatures. Histamine is a heterocyclic biogenic amine that is formed by decarboxylation from the amino acid histidine. It is a substance commonly found in food, especially in fish and fish products. The formation of histamine involves enzymes belonging to decarboxylases, which are produced by micro-organisms, most often from the *Enterobacteriaceae* family. The amount and rate of histamine formation are influenced by several factors, such as enzyme activity, process temperature, pH, water activity, and oxygen availability [72,73]. Histamine is most accumulated by tuna, mackerel, sardines, and horse mackerel. The level of histamine in fish and fish products is also influenced by the technological conditions of production [74]. In people intolerant to histamine, it causes food poisoning called scombroid poisoning or scombrotoxism [75,76].

The United States Food and Drug Administration (USFDA) established a defect action level of 50 mg/kg for histamine (according to the revised Guidance in year 2020), whereas the Commission Regulation (EC) No 2073/2005 fixed maximum levels of 200 and 400 mg/kg for raw fish and fish products subjected to enzyme maturation treatment in brine, respectively [73,77].

Preventing the formation of histamine in fish involves ensuring a proper cold chain from the catch to the finished fish product. Captured fish must be immediately placed on ice or frozen and their temperature must be controlled during transport and processing [77]. It is also very important to ensure hygiene and sanitation practices based on a Hazard Analysis and Critical Control Points (HACCP) approach to both the handling and processing of fish and fish products.

4.1.4. Heavy Metals

The high frequency of notifications related to the mercury content in fish and fish products is of concern (subsection "Heavy metals (mercury and cadmium)" and Table 3). Mercury began to be considered an environmental pollutant after the Minamata Bay disaster in Japan and after poisoning incidents caused by using mercury pesticides in agriculture [78]. Mercury occurs as metallic mercury, in the form of inorganic salts, and in organic compounds. Mercury accumulates readily and is toxic to organs such as the brain, liver, lungs, heart, and pancreas [79]. Recent research indicates that the toxic effects of mercury extend far beyond the nervous system and there is evidence of effects on the cardiovascular and immune systems. The World Health Organization (WHO) has recognized mercury as a neurotoxic and immunotoxic substance [80,81].

Mercury exposure occurs in combination with other toxins, as well as non-chemical stressors (e.g., nutrition) and factors (e.g., genetics), and the cumulative effects are poorly studied. The Minamata Convention obliges governments to limit the use and release of mercury into the environment to protect human health and the environment [82]. Qualitative measurements of mercury levels in human biological samples provide direct evidence of population exposure from which risk assessments can be made. These studies should be primarily conducted in communities for which fish and fish products constitute the basis of nutrition, as well as among communities exposed to mining activities [83].

Eissa et al., (2023) [84] analyzed 4728 notifications in the RASFF database regarding the six most frequently reported heavy metals (arsenic, cadmium, lead, mercury, chromium, and nickel) in the years 2000–2022. The results showed that the highest number of notifications concerned mercury (36.6%), with the number of total notifications peaking between 2011 and 2014; starting from 2015, it began to decline significantly. The most frequently reporting country was Italy, and approximately 91.5% of the mercury notifications concerned fish and fish products. Soler-Blasco et al., (2019) [85] noted the presence of mercury in swordfish from Spain. However, it is also worth noting that fish from other regions of the world may not be allowed into the European Union market and detained under border rejections [86].

Scientists reassure consumers that the moderate consumption of 1–2 portions of fish a week, especially fatty fish (e.g., salmon, herring, and sardines), is beneficial for health and the circulatory system due to the high content of n–3 polyunsaturated fatty acids. However, there is some concern that the mercury content in fish may increase the risk of cardiovascular disease, but this relationship remains unclear [87].

Another element identified in fish and fish products is cadmium. The RASFF notifications concerned the increased cadmium content in crabs imported from France to Italy [88]. Epidemiological data suggest that occupational and environmental exposures to cadmium may be associated with various types of cancer, including breast, lung, prostate, nasopharyngeal, pancreatic, and kidney cancer. Environmental cadmium has also been shown to be a risk factor for osteoporosis. The liver and kidneys are extremely sensitive to the toxic effects of cadmium [89]. People are exposed to the toxic effects of cadmium by eating contaminated food and smoking, including through employment in the metal industry or working in places contaminated with cadmium [90]. Seafood and some fish species, such as mullet (*Mullus barbatus barbatus*) and sardines (*Sardina pilchardus*) have a special ability to bioaccumulate this element [91–93].

4.1.5. Other Hazards

Problems are also noted in such hazard categories as food additives and flavourings, allergens, and composition. Ulca et al., (2010) [94] reported high levels of sulphites in dried fruits from Turkey. Adding sulphites to prawns and shrimps is a common practice [95], but this is not believed to cause a major health risk due to the occasional consumption of these products. In turn, the issue of undeclared allergens such as milk in chocolate was raised by Martínez-Pineda and Yagüe-Ruiz (2022) [96]. Sudan dyes are not permitted in Europe but are illegally used as colourants and have been found in sauces or chilli, which has led to the development of new detection methods [97,98]. However, to effectively reduce the aforementioned hazards, both manufacturers and food safety authorities must intensify their efforts.

The problem with the *Anisakis* parasite was noted by Rodrigues Caldeira et al., (2021) [99], who stated that in order to solve it, standardization in parasite detection is needed, and this requires the adoption of modern techniques and methodologies.

As for foreign bodies, Djekic et al., (2017) [100] show that they are most often associated with pests and glass. Insect incidence is usually related to crops, and glass is linked to production issues. Therefore, it is important to maintain proper hygienic and production practices.

4.2. Policy Implications Related to Turkey

Notifications on products originating from Turkey accounted for almost 40% of all notifications. Particularly worrying is also the fact that the number of notifications has risen sharply in recent years (Figure 1). These mainly concerned the presence of mycotoxins and pesticide residues in fruits and vegetables (subsections "Mycotoxins (aflatoxins and ochratoxin A)" and "Pesticide residues (chlorpyrifos, ethylene oxide, formetanate, chlorpyrifos-methyl, acetamiprid, oxamyl and prochloraz)").

Engelbert et al., (2014) [101] pointed out that fruits and vegetables are one of the most strategically important sectors for the movement of goods from Turkey to the European Union. In turn, Gunel et al., (2015) [102] noted that Turkey is a major global producer and exporter of fresh food and needs a powerful surveillance system in this area. Therefore, Golge et al., (2021) [103] recommended that the Turkish General Directorate of Food and Control implement a pesticide monitoring programme, especially regarding fruits and vegetables.

According to the Standard International Trade Classification (SITC) available in the Eurostat database for data since 1999, imports of fruits and vegetables from Turkey to the European Union between 1999 and 2021 increased by two times in volume and by two and a half times in value (Figure 4). Also significant is the fact that during this period, the average price of 1 kg of fruits and vegetables from this country rose by more than 30%, from €1.36 in 1999 to €1.82 in 2021 [104].

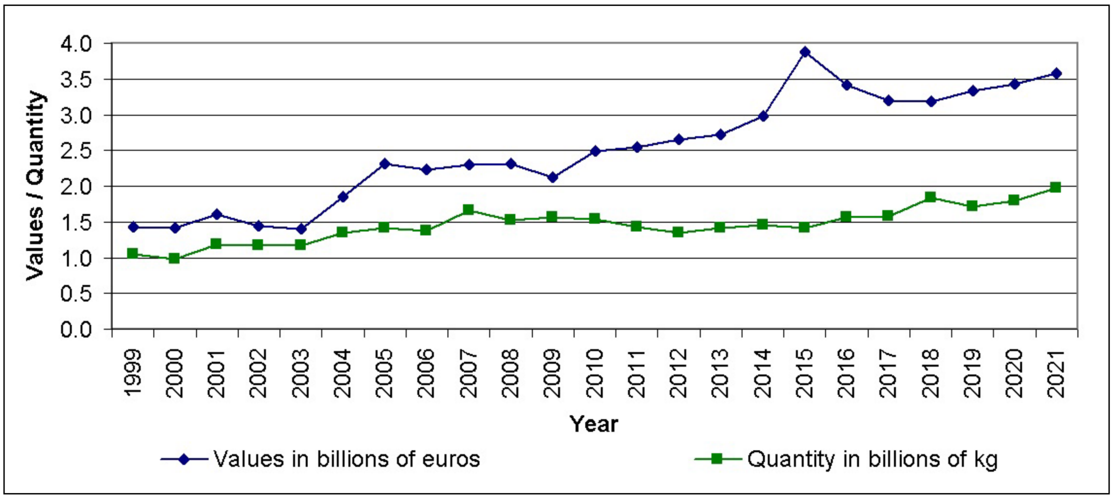

Figure 4. Imports of fruits and vegetables from Turkey to the European Union in 1999–2021.

The problem of mycotoxin and pesticide contamination in fruits and vegetables from Turkey can be a challenge for the border posts of Bulgaria and Greece, which share a land border with Turkey. This requires them to pay special attention to and detain these products within border rejections to prevent them from entering the common market. However, taking into account all types of notifications (i.e., not only border rejections but also alerts and information), the Pearson correlation coefficient between the quantity of fruits and vegetables imported from Turkey into the European Union and the number of notifications regarding them in the RASFF in 1999–2021 was 0.78 (test statistics = 5.77, and critical statistics = 2.08 by $\alpha = 0.05$ in two-tailed distribution) [105]. This indicates a high correlation, meaning that the number of notifications (of all types) depends mainly on the volume of imports from this country.

The notifications regarding heavy metals in seafood from Spain and France, which were reported by Italy, are also worth noting (subsection "Heavy metals (mercury and cadmium)"). According to the SITC, imports of fish, crustaceans, and molluscs from Spain to Italy increased by nearly 4 times (in value) and 2 times (in quantity) between 1999 and 2021, while from France by 2 times and 1.2 times, respectively [104]. Given the rising imports of these products, it therefore becomes necessary to strengthen the cooperation of the food safety supervisory authorities of the aforementioned countries. This is all the more important as the free movement of products is carried out within the common market.

4.3. Keyword Analysis Using VOSviewer

Figure 5 shows the network visualization after the analysis of the links between 95 keywords in VOSviewer 1.6.20. This map presents seven clusters in different colours.

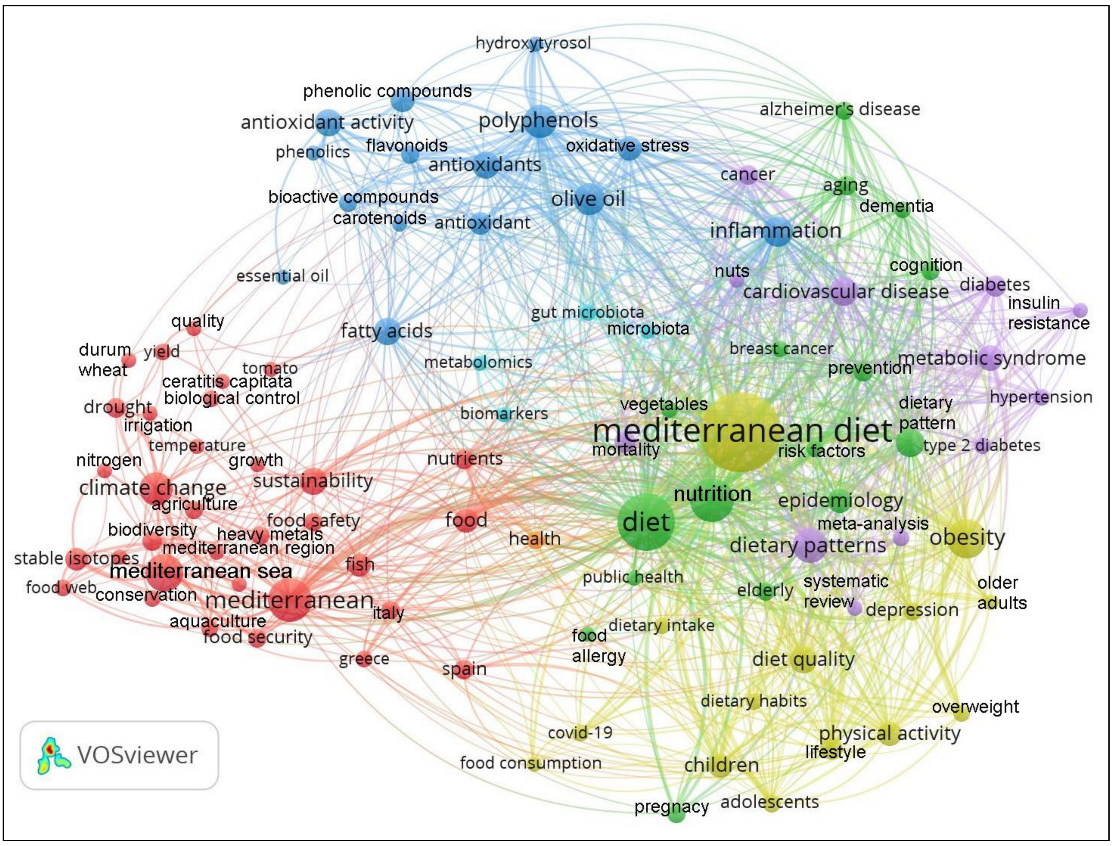

Figure 5. The network visualization carried out in VOSviewer taking into account the keywords indicated by authors of scientific works containing the words “Mediterranean*” and “food”.

The most frequently indicated keyword was “Mediterranean diet” in the olive cluster (right side of the visualization). Close to this word are “diet quality”, “dietary habits”, “dietary intake”, and “food consumption”, as well as “lifestyle” and ”physical activity”. This cluster also included ailments and diseases, such as “obesity”, “overweight”, “depression” and “COVID-19”. Also, importantly, the olive cluster includes people of different ages, i.e., “children”, “adolescents”, and “older adults”.

Similar issues are contained in the green cluster. The largest elements of the green cluster are related to food, i.e., “diet”, “dietary pattern”, “nutrition”, and “vegetables”, or health, i.e., “epidemiology”, “public health”, and “prevention”, and the word “pregnancy” was also included here. The other words in the green cluster, as in the olive cluster, refer to ailments or diseases, i.e., “risk factors”, “food allergy”, “breast cancer”, “dementia”, and “Alzheimer’s disease”. At some distance from the green cluster is an orange cluster containing only one “health” element (in the middle of the visualization).

In the purple cluster, are the elements “dietary patterns” and “nuts”, and the names of other elements are also related to diseases, i.e., “cancer”, “cardiovascular disease”, “diabetes”, “type 2 diabetes”, “insulin resistance”, “hypertension”, “metabolic syndrome”, and also “mortality”. Thus, it can be seen that the olive, green, and purple clusters cover similar issues and are mostly related to diet, age, and ailments or diseases. It is also important that these three clusters intermingle.

In the upper part of the visualization, there is a dark blue cluster, which mainly focuses on words related to chemical compounds (e.g., bioactive compounds, polyphenols, flavonoids, caretonoids, and fatty acids) and physico-chemical phenomena (e.g., antioxidant activity and oxidative stress). Whereas, below, in the central part of the map, is a light blue cluster with words such as "microbiota", "metabolomics", and "risk factors".

Finally, to the left of the visualization, some distance from the other clusters, is the red cluster. It covers different types of issues to those presented in the earlier clusters. The highest number of occurrences here are for words such as "mediterranean", "Mediterranean sea" and, particularly noteworthy, the word "sustainability". In the red cluster, there were also other related word issues relating to the environment, and these are "climate change", "biodiversity", "agriculture", "irrigation", "drought", "temperature", and "conservation". It is also worth noting that it is in this cluster that the word "food" has been included, as well as "food safety", "food security", and "nutrients". Some food types also appear here, such as "fish", "tomato", and "durum wheat"; hazards, such as "heavy metals" and "nitrogen"; and Mediterranean countries, including "Italy", "Spain", and "Greece". The absence of Turkey may be puzzling, but it should be recalled that a very high threshold for the minimum number of occurrences of keywords was adopted (i.e., 90—Section 2: Materials and Methods). It can also be surmised that Turkey may not be fully considered by the authors as a Mediterranean country, but one with a transitional climate.

The issues most frequently highlighted by authors of scientific works in recent years (i.e., from 2019 onwards) are marked in yellow in the overlay visualization (Figure 6). Additionally, red arrows mark those elements worth paying particular attention to.

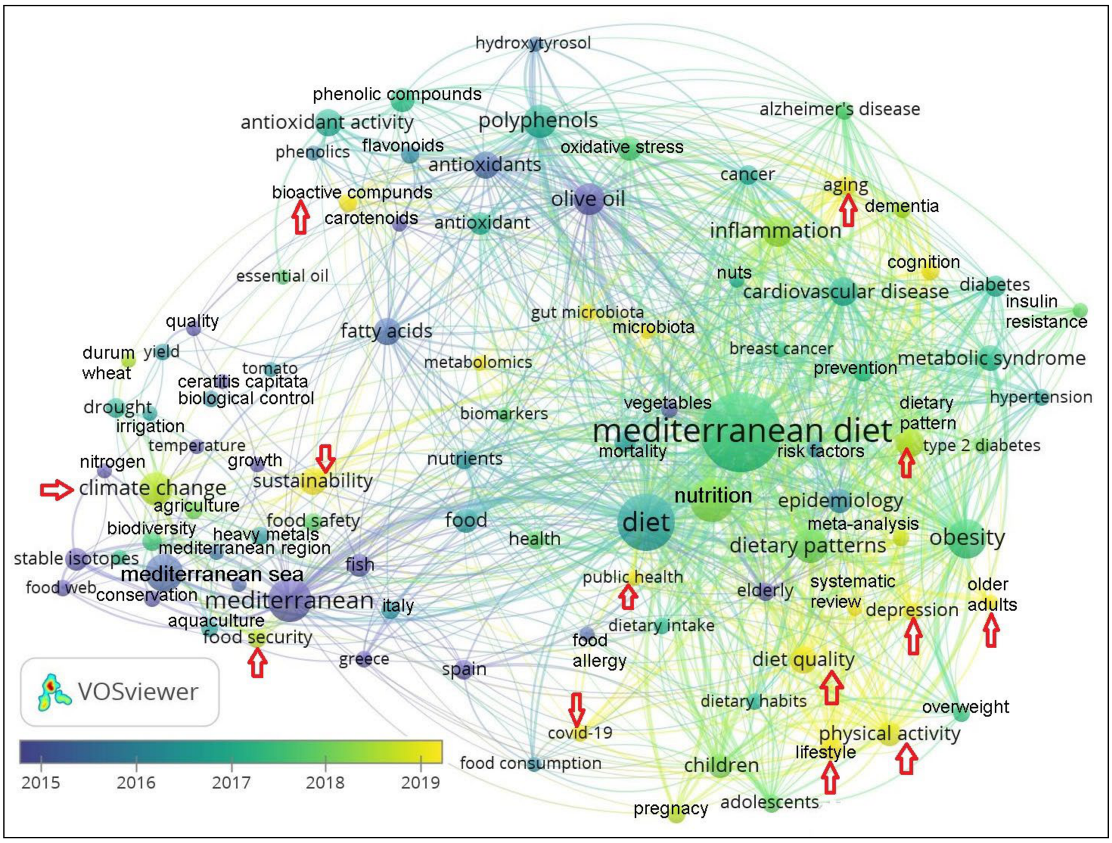

Figure 6. The overlay visualization carried out in VOSviewer taking into account the keywords indicated by authors of scientific works containing the words "Mediterranean*" and "food".

In the last few years, in view of the Mediterranean and food, the most common topics raised were those related to dietary patterns, diet quality, physical activity, and lifestyle. Also noted are issues related to ageing and older adults, as well as public health and diseases, i.e., depression and COVID-19 (right side of the visualization). The importance of bioactive compounds is also noted (upper part of the map). Finally, it should also be emphasized that sustainability issues have been combined with climate change and food security in the last few years (left side of visualization).

As a closing remark, it is worth noting that authors of scientific works on the Mediterranean and food link these issues to health (applying age-appropriate dietary patterns to prevent ailments and diseases) and environmental aspects, which is extremely significant in the context of sustainability. The need to change attitudes and behaviours in this regard therefore points to Mediterranean authorities as well as the public. However, it would also be appropriate to add the economic aspect related to food chain operators, e.g., producers, distributors, food sellers, and food service providers.

4.4. Limitations and Difficulties in Interpreting Data

For imported food products, the responsibility for detecting hazards rests with EU border posts. EU member state authorities also supervise food already on the single market. However, despite the existence of a common food law, several aspects should be noted that may have influenced the incomplete picture of hazards reported in the RASFF, e.g., the accession of new member countries to the European Union, differences in specific food legislation in different EU countries, the number and structure of control bodies, the experience and reporting practices of the staff of these bodies, and the flow of information between bodies from different countries. Attention should also be paid to the traditional presence of seafood in the Mediterranean diet, consumed raw or minimally processed (e.g., in Italy, France, and Spain), which can also generate hazards not communicated in the RASFF.

As noted in Section 2: Materials and Methods, the data for the study were extracted from the RASFF archive database, as the database currently available on the European Commission website only contains data from 2020 onwards. Importantly, the data exported from this database do not contain information on the hazard category (there are only hazards), product (there is only the product category), notification basis, and action taken. Such detailed data can only be obtained by analyzing each notification one by one. Thus, the data in the two databases are structured differently, and merging them would be possible, but difficult and labour-intensive, especially if it were to cover notifications from several years.

The colours on the legends of the charts generated in the two-way joining cluster analysis did not always match those on the actual chart, making the results difficult to read. Another limitation of this method is that it is significantly more difficult to follow trends over time, as the results representing the clusters were not grouped by consecutive years, but by a similar number of notifications. In turn, in the visualizations created in VOSviewer, not all elements were described, making it necessary to manually overwrite them in the graphics programme.

5. Conclusions

Notifications on products from Mediterranean countries accounted for 24.3% of all the notifications in the RASFF between 1997 and 2021. In recent years, they related mainly to ochratoxin A and pesticide residues in fruits and vegetables imported from Turkey; ethylene oxide, *Salmonella*, *Listeria*, and *Escherichia coli* in various products from France; mercury in swordfish from Spain; and *Anisakis* in seafood from France and Morocco.

In the case of Turkey and Morocco, notifications were made on the basis of border controls followed by the detention of the food consignment and its re-dispatch or destruction, indicating the activity of the European Union border posts. In turn, in the case of products from the EU, the notifications were based on official controls and companies' own checks, after which food was withdrawn from the market or recalled from consumers. Such actions testify to the vigilance of the EU countries' supervisory authorities as well as the awareness of the companies.

The pronounced presence of mycotoxins and pathogenic micro-organisms in food from the Mediterranean region may be the result of climatic changes (increased temperature and humidity, alternating drought, and excessive rainfall). This, in turn, results in the increased use of pesticides, so that their residues become detectable. It is worth noting here that fruits and vegetables from Turkey are contaminated with these compounds and can enter the common European market via the land border with Bulgaria and Greece. For most of the above-mentioned hazards, failure to respect the cold chain or a lack of proper production hygiene may also be a cause. However, the presence of the heavy metal mercury in swordfish from Spain, which may indicate industrial pollution, is also of concern.

Thus, in order to maintain food safety, producers, distributors, and retailers, both EU and non-EU, should strictly adhere to the principles of HACCP, Good Agricultural Practice (GAP), Good Manufacturing Practice (GMP), and Good Hygienic Practice (GHP), and maintain traceability throughout the food chain. This is particularly pertinent in the case of border controls, where the following can be recommended: the extension of control plans, training for inspectors from exporting countries, joint controls by inspectors from the exporting and importing country, and control in the exporting country at wholesale.

As the keyword analysis has shown, studies carried out in recent years in relation to food and the Mediterranean link sustainability with environmental aspects and food security, which could also be important to counter food waste. In turn, when considering the social aspect of sustainability, the authors of these research papers draw attention to age and adequate diet, which is vital to prevent ailments and diseases.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su17030889/s1: Figure S1: Results of cluster analysis for aflatoxins; Figure S2: Results of cluster analysis for ochratoxin A; Figure S3: Results of cluster analysis for chlorpyrifos; Figure S4: Results of cluster analysis for ethylene oxide; Figure S5: Results of cluster analysis for formetanate; Figure S6: Results of cluster analysis for chlorpyrifos-methyl; Figure S7: Results of cluster analysis for acetamiprid; Figure S8: Results of cluster analysis for oxamyl; Figure S9: Results of cluster analysis for prochloraz; Figure S10: Results of cluster analysis for *Salmonella*; Figure S11: Results of cluster analysis for *Listeria*; Figure S12: Results of cluster analysis for *Escherichia coli*; Figure S13: Results of cluster analysis for *Campylobacter*; Figure S14: Results of cluster analysis for norovirus; Figure S15: Results of cluster analysis for moulds; Figure S16: Results of cluster analysis for histamine; Figure S17: Results of cluster analysis for mercury; Figure S18: Results of cluster analysis for cadmium; Figure S19: Results of cluster analysis for sulphite; Figure S20: Results of cluster analysis for colour; Figure S21: Results of cluster analysis for milk; Figure S22: Results of cluster analysis for Sudan; Figure S23: Results of cluster analysis for *Anisakis*; Figure S24: Results of cluster analysis for insects; Figure S25: Results of cluster analysis for glass; Figure S26: Results of cluster analysis for foodborne outbreaks; Figure S27: Results of cluster analysis for health certificate(s); Figure S28: Results of cluster analysis for diarrhoeic shellfish poisoning (DSP) toxins; Figure S29: Results of cluster analysis for benzo(a)pyrene; Figure S30: Results of cluster analysis for poor temperature control; each of Figures S1–S30 consists of seven panels marked with the letters: (a) product; (b) country of origin; (c) notifying country; (d) notification type; (e) notification basis; (f) distribution status; (g) action taken. Table S1: Results of the cluster analysis related to notifications of mycotoxins in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S2: Results of the cluster analysis related to notifications of pesticide residues in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S3: Results of the cluster analysis related to notifications of pathogenic micro-organisms and microbial and biological contaminants in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S4: Results of the cluster analysis related to notifications of heavy metals in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S5: Results of the cluster analysis related to notifications of food additives and flavourings, allergens, and composition in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S6: Results of the cluster analysis related to notifications of parasitic infestation in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S7: Results of the cluster analysis related to notifications of foreign bodies in products from Mediterranean countries reported in the RASFF in 1997–2021; Table S8: Results of the cluster analysis related to notifications of other hazards in products from Mediterranean countries reported in the RASFF in 1997–2021.

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Abbreviations

The following abbreviations are used in this manuscript:

AFB1	aflatoxin B1
AFB2	aflatoxin B2
AFG1	aflatoxin G1
AFG2	aflatoxin G2
AFM1	aflatoxin M1
DSP	diarrhoeic shellfish poisoning
EFSA	European Food Safety Authority
EU	European Union
GAP	Good Agricultural Practice
GHP	Good Hygienic Practice
GMP	Good Manufacturing Practice
HACCP	Hazard Analysis and Critical Control Points
MRLs	maximum residue levels
RASFF	Rapid Alert System for Food and Feed
SITC	Standard International Trade Classification
USFDA	United States Food and Drug Administration
WHO	World Health Organization
WoS	Web of Science

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