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Notifications Related to Fraud and Adulteration in the Rapid Alert System for Food and Feed (RASFF) in 2000–2021

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Abstract: Fraudulent and adulterated food is produced mainly to reduce prices and attract consumers' attention whilst threatening their economic interests, health, and safety. As such, this type of activity should be eliminated. This study's aim was to identify the most common hazards related to food fraud and adulteration, reported in the Rapid Alert System for Food and Feed (RASFF) between 2000 and 2021, taking into account the product category (including individual products), country of origin, and notification type. We used Microsoft Excel (filtering, vertical-searching, transposition, and pivot table functions) and Statistica 13.3 (two-way joining cluster analysis) to analyse similarities between the hazards identified throughout the research period. Notifications relating to food fraud and adulteration accounted for 18.7% of all RASFF notifications, fluctuating between 1000 and 1200 per year in recent years. These mainly included hazards related to composition and novel foods in dietetic foods, food supplements and fortified foods, sulphites in fruits and vegetables, colours in cereals and bakery products, or Sudan in herbs and spices. Dietetic foods, dietary supplements, and fortified foods were mainly reported as alerts and information notifications, meaning that they were already available on the common European internal market. The other products originated mainly from outside the European Union (Asia—Turkey, Uzbekistan, India and Africa—Ghana, Nigeria) and were submitted on the basis of border rejections. Therefore, it is necessary to continue closely monitoring imported products at the EU border to ensure food safety, avoiding fraud and adulteration and protecting consumers' financial interests.

Keywords: European Union; food fraud and adulteration; food safety; RASFF; cluster analysis

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1. Introduction

Food fraud and adulteration issues occupy a special place in food safety, with the latter having been a problem since ancient times. Two hundred years have passed since the publication of "*A treatise on adulterations of food and culinary poisons*", an important work discussing the topic of food adulteration for the first time in modernity. The book, which was released in 1820, revealed the adulteration in most samples of milk, flour, beer and other drinks, sweets, and many other food products and flavourings available commercially in Great Britain. The author, Frederick Accum, was accused of causing social unrest; however, regardless of the controversy it created, his work was the first to draw attention to the quality of food available in Britain. Since then, the issue of food adulteration has been addressed in Germany, France, and the United States, where the Food and Drug Administration (FDA) was established in 1906 [1–3].

An important problem in food adulteration is the definition of concepts, i.e., terminology, as the meanings of terms such as fraud, forgery, and authenticity are essential for understanding the essence of the issue and establishing legal food safety provisions. Thus far, many researchers have presented their position on defining irregularities such as fraud, falsification, or lack of authenticity [4–8], but, regardless of these semantic considerations,

the consequence of falsification may be a public threat. This concept is also defined differently in the literature. One of these definitions is included in the ISO 22000 standard, where a food safety hazard is "a biological, chemical, or physical agent in, or condition of, food with the potential to cause an adverse health effect" [9]. A similar definition of risk is contained in Regulation (EC) 178/2002 (General Food Law) [10]. The evolution of these terms and concepts was demonstrated by Spink et al. [7] in relation to event, incident, hazard, crisis, threat, vulnerability, and risk. Discussions over the terminology of food authenticity continue to this day. Most often, authenticity refers to the comparison of a product with a standard that is recorded in an appropriate legal act or certified by a quality certificate. The authenticity of food has become a source of competitive advantage and the main attribute of traditional, regional, and organic food [11]. In this context, it seems easier to show inauthenticity than define the attributes of authenticity [12].

Despite increasing surveillance, fraud and adulteration continue to occur in food production and distribution. At the end of the 20th century and the beginning of the 21st century, food safety threats occurred several times in Europe, including, for example, the presence of dioxins in feed intended for poultry as well as the adulteration of beef with horse meat [13,14]. The European Union (EU) responded to these events by introducing appropriate legal provisions.

The 2019 European Food Safety Authority (EFSA) report on activities to address emerging risks stated that foresight could support actions outside of the Food Safety Program, including sustainable production issues and food fraud, the latter of which has received extra attention [15]. Then, the Farm-to-Fork Strategy emphasised the fact that food fraud threatened food systems' sustainability, as deceiving consumers rendered them unable to make informed choices, as well as food safety, fair trading practices, food markets' resilience, and, finally, the single market. This strategy also pointed out that cooperation between EU countries, Europol, the European Anti-Fraud Office (OLAF), and other bodies was needed to prevent food fraud [16].

The EU law sets very high food safety requirements, which also include fraud and adulteration. One of the tools ensuring food safety is the Rapid Alert System for Food and Feed (RASFF), a system whose members—the EU and European Economic Area (EEA) countries—are obliged to exchange information on public health risks in the food chain, supervised by the European Commission. RASFF's current legal basis is Regulation (EC) 178/2002.

RASFF alert notifications are sent when food presenting a serious health risk is on the market, requiring rapid action. The RASFF member who has identified such a risk takes appropriate measures (e.g., product withdrawal) and notifies other system members, who check whether the reported product is on their market and, if so, also take proper action. Border rejections concern products tested and rejected at the EU's external border when a health risk has been found. In this case, notifications are sent to other EU border posts to prevent this product from entering the common EU market. RASFF information notifications, instead, are sent when a risk has been identified, not requiring rapid action. This is the case when the product has not yet reached the market or is no longer on it and when the nature of the risk does not call for rapid measures [17].

The number of RASFF notifications in the food fraud and adulteration hazard categories between 2000 and 2021 is presented in Figure 1 (cumulative column chart). In the earlier years of operation of the system, this number ranged between only a few to around 10 notifications per year.

The notifications related to fraud and adulteration accounted for 18.7% of all RASFF notifications between 2000 and 2021, with composition having the highest percentage (33.8%), followed by food additives and flavourings (25.6%), allergens (17.8%), adulteration/fraud (14.6%), and novel food (8.1%). Since 2000, the number of notifications has rapidly increased, fluctuating, in recent years, between 1000 and 1200 annually.

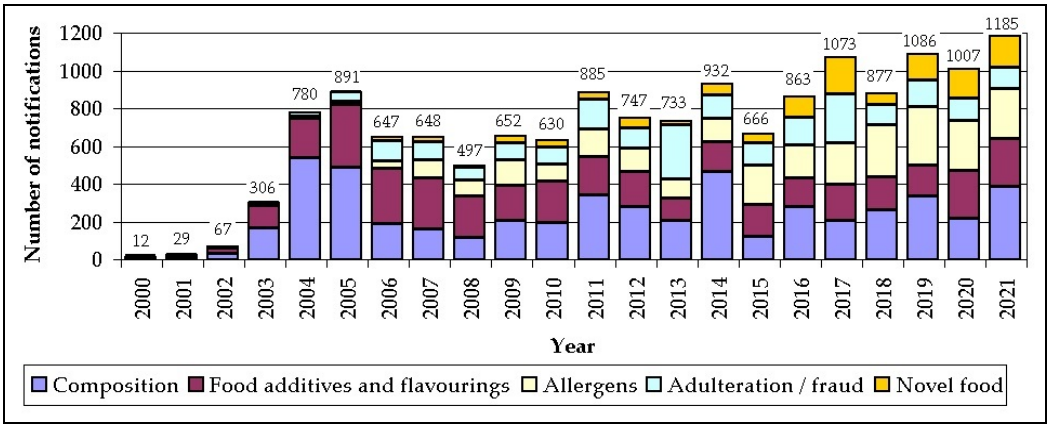


Figure 1. Number of RASFF notifications in hazard categories concerning fraud and adulteration reported between 2000 and 2021.

The issue of RASFF notifications of food fraud and adulteration has been addressed in scientific papers, but a cross-sectional study covering a wide time range and different variables is lacking. Therefore, this study's aim was to identify the most common hazards related to food fraud and adulteration reported in RASFF between 2000 and 2021, taking into account the product category (including individual products), country of origin, and notification type.

2. Data and Methods

Data were obtained from the restored RASFF database maintained by the European Commission, and they covered 15,221 notifications from 2000 to 2021 in the hazard categories of composition (5149), food additives and flavourings (3903), allergens (2704), adulteration/fraud (2227), and novel food (1238) [18]. Finally, these data were combined in a single Microsoft Excel 365 (Microsoft Corporation, Redmond, WA, USA) sheet containing the following columns: hazard, hazard category, year, product category, product, country of origin, and notification type. It is worth noting that the (official) RASFF database currently available only contains data from 2020 onwards (no historical data) [17], is organised differently, and the exported data lack information on hazard category and product [19].

The data were then processed in Microsoft Excel using the filtering, vertical-searching, transposition, and pivot table functions. To identify the most frequently reported hazards and how they aligned with one another, a two-way joining cluster analysis in Statistica 13.3 (TIBCO Software Inc., Santa Clara, CA, USA) was conducted. This is a two-dimensional analysis that allows the discovery of significant clusters and is used when the values contained in both the columns (in our case, hazards) and rows (in this case, years) of a pivot table can be expected to simultaneously contribute to the discovery of meaningful cluster patterns. Although the structure of the resulting clusters is, by nature, not homogeneous, a two-way joining cluster analysis is considered to be a powerful tool for data exploration [20].

The results of this analysis are represented with a chart showing the clusters by colours (and their shades), from green to brown (the most significant clusters), with the same colours indicating similarities. Because of the adopted method's constraints, the number of hazards analysed was reduced to the 30 most frequently reported ones. For the ten hazards with the highest number of notifications (47.0% of all notifications related to fraud and adulteration), a detailed analysis was carried out using pivot tables, identifying relationships between the following variables: product category (including individual products), country of origin, and notification type.

To explore the link between the words "fraud" and "adulteration" and other keywords indicated by authors of scientific papers from 2000 to 2021, a search was conducted in the Web from Science database using the phrase "food AND fraud OR adulteration". This yielded 9337 records [21], which were exported in text files of 1000 records each and then

merged into a single file. These data were then analysed in VOSViewer 1.6.20 (Centre for Science and Technology Studies, Leiden University, The Netherlands). The following options were used: type of analysis (co-occurrence), unit of analysis (author keywords), counting method (full counting) and minimum number of occurrences of the keyword (15). The results of this analysis were presented in two maps: a network visualisation map and an overlay visualisation map [22,23].

3. Results

The results of the two-way joining cluster analysis for fraud- and adulteration-related RASFF notifications between 2000 and 2021 are shown in Figure 2.

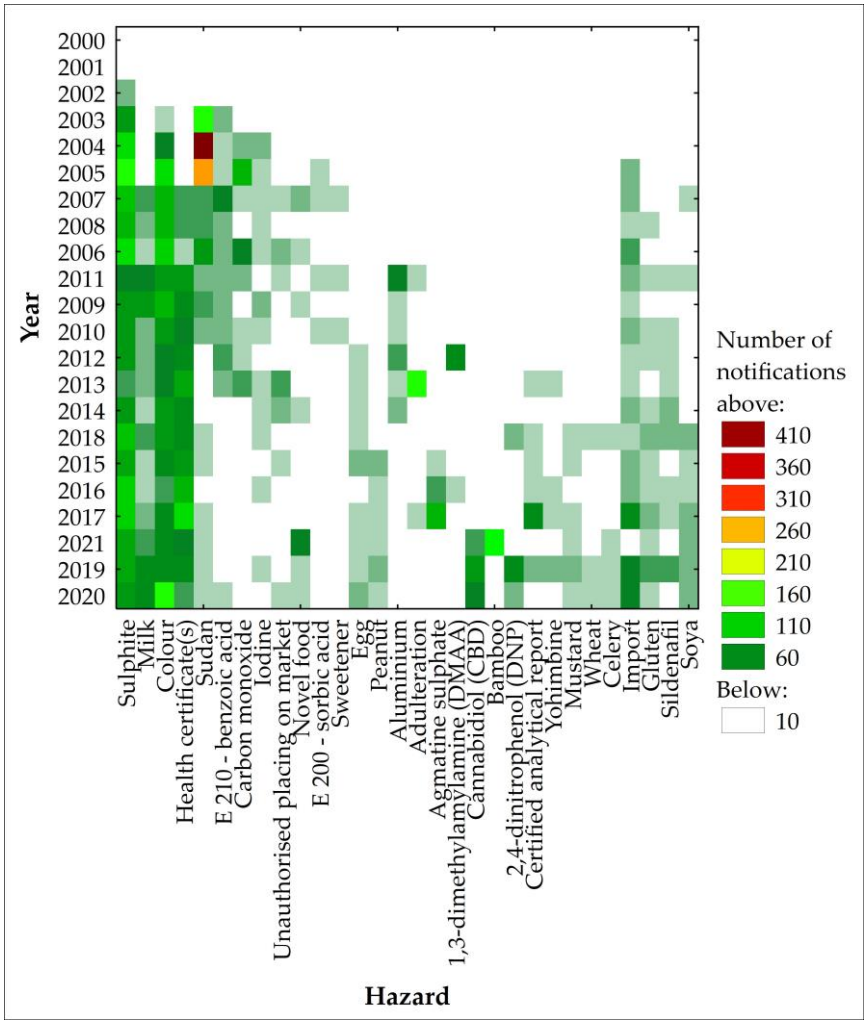


Figure 2. Results of the two-way joining cluster analysis for fraud- and adulteration-related RASFF notifications between 2000 and 2021.

Due to the analysis, clusters are grouped according to the number of notifications (not by year), with Sudan colour (dye) reaching a significant number of notifications in 2004 (orange) and 2005 (brown, with over 410 notifications). A considerable part of the chart, on the left-hand side, is covered by other clusters, concerning notifications from 2007 to 2021, related to hazards such as sulphite, milk, colour, and health certificate(s). These clusters are marked with different green shades, with numbers varying between 210 and 10. During the same period, there were also notifications concerning imports, as can be seen on the right-hand side. It is also worth noting that the remaining (and larger) part of the figure is occupied by white clusters (less than 10 notifications).

The number of fraud and adulteration RASFF notifications of the ten most frequently reported hazards between 2000 and 2021, including the full name of the hazards, the hazard categories, and the years, is presented in Table 1. Only the years during which the number of notifications for a given hazard exceeded the mean value are listed. The individual elements are presented in the descending order of the number of notifications.

Table 1. Number of RASFF notifications for fraud- and adulteration-related hazards between 2000 and 2021 (full name of hazard, hazard categories, and years).

Hazard	Full Name of Hazard	Hazard Category	Years
Sulphite (1601)	Too high content of sulphite (1104), Sulphite undeclared (443), Sulphite unauthorised (54)	Food additives and flavourings (1158), Allergens (443)	2004–2008, 2015–2018, 2021
Colour (1322)	Unauthorised use of colour E 127—erythrosine (158), Unauthorised use of colour E 102—tartrazine (129), Unauthorised use of colour E 110—Sunset Yellow FCF (126), Too high content of colour E 110—Sunset Yellow FCF (121), Unauthorised use of colour E 160b—annato/bixin/norbixin (82), Too high content of colour E 124—Ponceau 4R/cochineal red A (67), Unauthorised use of colour E 124—Ponceau 4R/cochineal red A (67), Unauthorised use of colour E 122—azorubine (60), Unauthorised use of colour E 123—amaranth (54), Unauthorised use of colour E 171—titanium dioxide (48), Other (410)	Food additives and flavourings (1305), Composition (17)	2005–2010, 2014, 2018, 2020
Sudan (1224)	Unauthorised colour Sudan 1 (674), Unauthorised colour Sudan 4 (516), Unauthorised colour Sudan 3 (21), Unauthorised colour Sudan Red G (4), Unauthorised colour Sudan (3), Unauthorised colour Sudan 2 (2), Unauthorised colour Sudan 7B (2), Unauthorised colour Sudan Orange G (1), Unauthorised colour Sudan Red B (1)	Composition	2003–2006
Health certificate(s) (891)	Absence of health certificate(s) (450), Improper health certificate(s) (281), Fraudulent health certificate(s) (117), Expired health certificate(s) (24), Suspicion of fraudulent health certificate(s) (19)	Adulteration/fraud	2009–2019, 2021
Milk (518)	Milk ingredient undeclared (405), Traces of milk (106), Presence of milk (7)	Allergens	2007, 2009, 2011, 2018–2021
Import (461)	Attempt to illegally import (293), Illegal import (118), Unauthorised import (32), Suspicion of attempt to illegally import (12), Suspicion of illegal import (6), Import for direct consumption (1)	Adulteration/fraud	2005–2007, 2010–2011, 2014, 2016–2017, 2019–2020
Benzoic acid (E 210) (338)	Too high content of benzoic acid E 210 (234), benzoic acid E 210 unauthorised (89), benzoic acid E 210 undeclared (15)	Food additives and flavourings	2003, 2006–2013
Carbon monoxide (283)	Carbon monoxide treatment (276), Suspicion of carbon monoxide treatment (7)	Composition	2004–2006, 2010–2013
Gluten (261)	Gluten undeclared (192), Too high content of gluten (40), Traces of gluten (16), Presence of gluten (13)	Allergens	2010–2011, 2014–2021
Iodine (252)	High content of iodine (243), Iodine undeclared (6), Absence of iodine (1), Too high intake of iodine (1), Too low content of iodine (1)	Composition	2004–2006, 2008–2010, 2014, 2018–2019

Too-high contents of sulphites, colours, benzoic acid (E 210), gluten, and iodine were mentioned in the notifications. An undeclared compound was reported most frequently for sulphites, milk, and gluten, as well as the unauthorised use of sulphites, colours, Sudan

dye (most often Sudan 1 or 4), and benzoic acid. Sulphites, colours, and benzoic acid were reported in the "food additives and flavourings" category, and sulphites were also notified as allergens, alongside milk and gluten. Colours, Sudan dye, carbon dioxide, and iodine were reported in the "composition" category, while health certificate- and import-related hazards were categorised under "adulteration/fraud". Problems with hazards such as Sudan dye, benzoic acid, and carbon monoxide were reported in the earlier years, while the others are an ongoing concern.

The fraud and adulteration hazards reported in the RASFF between 2000 and 2021 (product categories, countries of origin, and notification type) are shown in Table 2, based on a pivot table analysis. The notification type is given according to the number of notifications, in descending order.

Table 2. Fraud- and adulteration-related hazards reported in the RASFF between 2000 and 2021 (product categories, countries of origin, and notification type).

Hazard	Product Category (Product)	Country of Origin	Notification Type
Sulphite	Fruits and vegetables (apricots)	Turkey, Uzbekistan, Greece, Iran	Border rejections, Information
	Fruits and vegetables (raisins)	Turkey, Uzbekistan	Border rejections, Information
	Crustaceans and products thereof (prawns, shrimps)	France, Spain, Brazil, Tunisia	Information, Alerts
Colour	Cereals and bakery products (breakfast cereals)	The United States	Border rejections
	Fruits and vegetables (chickpeas)	Turkey	Information
	Confectionary (fennel seeds)	India	Border rejections, Information
Sudan	Herbs and spices (chilli powder, curry powder, paprika powder)	India, Turkey	Border rejections, Alerts, Information
	Fats and oils (palm oil)	Ghana, Nigeria, Senegal	Information, Alerts, Border rejections
Health certificate(s)	Fruits and vegetables (figs), Nuts, nut products and seeds (hazelnuts)	Turkey	Border rejections, Information
	Nuts, nut products and seeds (sesame seeds), Herbs and spices (chilli powder, curry leaves), Fruits and vegetables (betel leaves)	India	Border rejections, Alerts
	Nuts, nut products and seeds (groundnuts, peanuts), Cereals and bakery products (rice noodles)	China	Border rejections, Information
	Herbs and spices (nutmeg)	Indonesia	Border rejections
Milk	Cocoa and cocoa preparations, coffee and tea (dark chocolate)	Germany	Alerts
Import	Fruits and vegetables (beans), Nuts, nut products and seeds (melon seeds)	Nigeria	Border rejections
	Fruits and vegetables (paan leaves)	Bangladesh	Border rejections
	Nuts, nut products and seeds (groundnuts), Fish and fish products (fish)	Ghana	Border rejections
Benzoic acid (E 210)	Non-alcoholic beverages (soft drinks, energy drinks)	The United States, Nigeria	Border rejections, Information
Carbon monoxide	Fish and fish products (tuna)	Spain, The Netherlands, Indonesia	Information, Alerts
Gluten	Cereals and bakery products (various products)	Germany, Poland	Alerts, Information
Iodine	Fruits and vegetables (seaweed, algae)	China, Republic of Korea, Japan, The Netherlands, France	Alerts

Most of the products reported originated from Asia and Africa, with border rejections as the notification type. This means that the products were detained at the European Union's border and did not enter the common market. The most notable were fruits and vegetables from Turkey (apricots, raisins, chickpeas, and figs), Uzbekistan (apricots and raisins), India (betel leaves), Bangladesh (paan leaves), and Nigeria (beans). These notifications included hazards such as sulphites, colours, and problems with health certificates

and import. In the "fruits and vegetables" product category, iodine in seaweed and algae, mainly from Asia (China, Korea and Japan), was also noted.

The next category was "herbs and spices", comprising products from Turkey and India (chilli, curry, and paprika powder) as well as Indonesia (nutmeg), with Sudan dye and health certificate hazards reported. The nuts and seeds from Turkey (hazelnuts), India (sesame seeds), China (groundnuts and peanuts), Nigeria (melon seeds), and Ghana (groundnuts), were also noteworthy, presenting health certificate and import problems.

The cereals and bakery products that were also the subject of RASFF notifications came from the United States (colours in breakfast cereals), China (problems with health certificates for rice noodles), and Germany and Poland (gluten in various products). In turn, fish came from Ghana (where import problems were reported) and Spain, Italy, and Indonesia (carbon monoxide in tuna).

Nevertheless, it should be noted that the highest number of hazards was reported in the "dietetic foods, food supplements, fortified foods" product category (more than 3500). However, these were very diverse (comprising more than 350 different hazards) and, therefore, are not indicated in the cluster analysis. The most frequently reported hazards in this category included the following: sildenafil, yohimbine, 1,3-dimethylamylamine (DMAA) and 2,4-dinitrophenol (DNP) (hazard category "composition"); agmatine sulphate, cannabidiol (CBD), and unauthorised novel foods (hazard category "novel food"); and unauthorised placement on the market (hazard category "adulteration/fraud"). These products were mainly reported through alerts and information notifications.

4. Discussion

4.1. Determinants Concerning Food Fraud and Adulteration Hazards

The growing number of fraud and adulteration hazard notifications (Figure 1) stemmed, on the one hand, from effective supervision and monitoring services and the increased reporting of these events and, on the other, from improving research tools and implementing analytical methods to identify these irregularities. The development of spectrophotometric and chromatographic methods and the use of various other analytical techniques allow for an increasingly accurate differentiation of the complex composition of food products. Recently, DNA-based techniques have been applied for species/variety identification and discrimination but also product traceability [24,25].

The fraud and adulteration hazards mentioned in the RASFF annual reports among the top 10 in terms of number of notifications are presented in Table 3. It is worth noting that all of these hazards are also visible in Figure 2.

Table 3. Fraud and adulteration notifications in the RASFF annual reports.

Hazard	Product Category	Year	Additional Information	Reference
Carbon monoxide treatment	Fish and fish products	2013	Country of origin: Spain, Notifying country: Italy	[26]
Absence of a health certificate	Nuts, nuts products and seeds	2017	Notifying country: the United Kingdom	[27]
Unauthorised novel food	Dietetic food, food supplements, fortified food	2017	Country of origin: the United States	[27]
2,4-dinitrophenol (DNP)	Dietetic food, food supplements, fortified food	2018	Notifying country: the United Kingdom	[28]
2,4-dinitrophenol (DNP)	Dietetic food, food supplements, fortified food	2019	Notifying country: the United Kingdom	[29]

The RASFF annual reports include two separate lists of the top 10 hazards in terms of notification number—by country of origin and notifying country. In 2013, only the number of notifications for carbon monoxide in fish was high enough to appear on both lists: the products originated from Spain and were reported by Italy [26].

The second hazard was the absence of a health certificate for nuts and seeds, reported by the United Kingdom in 2017 [27]. Owolabi et al. [30] noted that as nuts are a significant export product from the United States to the European Union, they have been subject to aflatoxin content certification since 2015. Thus, the absence of such a health certificate is important for nuts imported from Asian countries such as India and China. Additionally, Owolabi and Olayinka [31] have drawn attention to the Indonesian export of adulterated herbs and spices without proper health certificates and analytical test reports (Table 2). Both hazards (carbon monoxide and the absence of a certificate) were also identified in our analysis (Tables 1 and 2).

The other hazards that ranked in the top 10 by notification number in the RASFF annual reports belonged to the product category of "dietetic food, food supplements, fortified food", including unauthorised novel foods from the United States in 2017 and DNP reported by the United Kingdom in 2018 and 2019 [27–29].

The hazards reported in this category are of great concern, especially the presence of DNP in dietary foods, dietary supplements, and fortified foods. Although DNP is a substance which reduces body weight and fat tissue by uncoupling oxidative phosphorylation, it is also highly toxic, with small differences between the doses leading to weight loss and those causing severe poisoning or death. In 2012 and, especially, in 2013, the United Kingdom's network of poison centres reported a sharp increase in the number of reported cases and fatalities. Unfortunately, this practice continues, as evidenced by RASFF notifications (Table 3), and the increase in DNP exposure episodes and deaths is likely related to its availability for online purchase [32].

It is also important to note the significant number of notifications concerning supplements and sildenafil, yohimbine, DMAA, and agmatine sulphate. Sildenafil, or Viagra, is a chemical substance used in dietary supplements as an aphrodisiac, similar to yohimbine, obtained from *Pausinystalia yohimbe* bark [33], although the latter and its preparations have been banned in food since 2019 [34]. Also found in supplements, DMAA is a chemical geranamine obtained from geraniums (*Pelargonium odorantissimum*) that is used as a doping agent in sports and was prohibited, in 2009, by the World Anti-Doping Agency (WADA). Like the previous compounds, it has no connections with food. Agmatine sulphate, a chemical substance derived from the amino acid arginine, has quite a broad effect and, like DMAA, is used in sports to increase muscle mass by increasing testosterone levels. However, agmatine has therapeutic potential as an endogenous neuromodulator in the treatment of central nervous system disorders [35].

The 2021 and 2022 annual reports were not just about RASFF but of a different, broader nature, issued under the Alert and Cooperation Network. The 2021 report mentions adulterated herbs and spices, where undeclared plant material was found in pepper, cumin, turmeric, saffron, and paprika/chilli. Suspicions of illegal tuna processing using carbon monoxide, nitrates and nitrites, abuse of additives (citric acid and ascorbic acid), and deficiencies in labelling were also highlighted. Other adulterations identified in 2021 included water in frozen pangas and shrimps, olive oil or virgin olive oil sold as extra virgin olive oil, forged meat and poultry documentation, plants containing unauthorised substances for their protection, a different than declared composition of dietary foods, and adulterations of honey (extraneous sugars) and nuts [36].

In 2022, the number of adulteration-related notifications increased significantly, though the products concerned were similar to those from the previous year. The most notable hazard was product tampering (substitution) in the case of honey and crustaceans, followed by the unapproved/undeclared treatment of dietetic foods, fish, and non-alcoholic beverages. The notifications also concerned the grey market, mainly involving smuggling, illegal imports, and the production and trade of plant protection products and dietetic foods, as well as misdescription/mislabelling/misbranding in terms of quality and quantity [37].

The RASFF notifications show that hazards are very often submitted in two categories—food additives and flavourings and allergens (Table 1)—including cases of exceeding the permitted sulphite amount and failure to declare the addition of sulphites in dried fruits and

seafood (Table 2). Although food additives play an important role in the food industry, there are health risks associated with some of them [38], including, among others, sulphur dioxide (E 220), sodium sulphite (E 221), sodium hydrogen sulphite (E 222), sodium metabisulphite (E 223), potassium metabisulphite (E 224), calcium sulphite (E 226), calcium hydrogen sulphite (E 227), and potassium hydrogen sulphite (E 228) [10]. These compounds act as preservatives and good antioxidants, inhibit micro-organism growth, and help stabilise a product's colour, preventing discolouration and improving its appearance and taste during preparation, storage, and distribution. Sulphites are used to preserve vegetables and fruits, fish and seafood, meat products, wine, and other beverages [39,40].

However, sulphites can cause a variety of allergic symptoms, including abdominal pain, diarrhoea, dermatitis, hives, hot flashes, hypotension, and bronchoconstriction in patients with asthma, as well as anaphylactic reactions [40]. Therefore, in 1986, the US FDA decided to label food products with sulphite concentrations higher than 10 mg/L [41]. However, research conducted in Spain and Morocco shows that the sulphite content was high in many food products, mainly dried fruits, mustard, meat products, and potato chips. They were even detected in products to which their addition is prohibited, such as olives or mayonnaise [39,42]. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has set an acceptable daily intake (ADI) of sulphites at 0.7 mg/kg body weight expressed as sulphur dioxide [43].

The presence of prohibited dyes such as Sudan 1–4 in herbs and spices is also of great concern. Spices are a valuable group of food products with great importance in nutrition and food technology. They are mainly used to shape the sensory properties of food in gastronomy, home cooking, and the food industry. Ensuring spice quality and safety is one of the basic tasks of spice producers. Sudan 1–4 dyes are not approved worldwide as food additives due to their carcinogenicity. However, in view of their excellent colouring properties, they are used for illegal colouring of spices (chilli, peppers, and tomato paste), palm oil, and others. Palm oil is most often contaminated with Sudan 4 and comes from various African countries (Table 2). The European Commission has adopted Decision 460/2003, banning the use of Sudan dyes as food colours [44]. Currently in force in this respect is the Regulation (EU) 2019/1793 on the temporary increase of official controls and emergency measures governing the entry into the Union of certain goods from certain third countries [45].

Another group of prohibited colours (dyes) whose presence has been detected in food products comprises yellow azo dyes, represented, among others, by tartrazine (TTZ, E 102) and Sunset Yellow (SY, E 110) (Tables 1 and 2). These dyes are characterised by a colour ranging from yellow to orange, and are eagerly used to enhance the colour of food products, such as flavoured and fermented drinks, ice cream, cheese, spices, confectionery, chewing gum, jams, jellies, desserts, soups, fish roe, fish and shellfish pastes, breakfast cereals, and potato chips. Red dyes, including carmoisine (CAR), azorubine (E 122), and Ponceau 4R, better known as cochineal red A (E 124), are also commonly used in drinks and foods such as jellies, jams, candies, lollipops, yogurts, etc., when food undergoes heat treatment after fermentation [46]. Food products containing these dyes are eagerly consumed by children. It is believed that synthetic food dyes may affect children's behaviour and have neurobehavioural effects in children with identified behavioural disorders (particularly attention and activity disorders). There are serious concerns about a possible link between exposure to synthetic food dyes and the exacerbation of attention deficit hyperactivity disorder (ADHD) symptoms in children [47].

Spice adulteration with an undeclared plant material mainly concerns spice mixtures, as the strong fragmentation of these products masks the presence of both raw plant materials of other origin and substances such as dyes or compounds, improving their taste [48]. In spice mixtures, a specific spice variety is often partially or completely replaced with a lower-quality variety, mainly influenced by the spice's availability and price [49].

The increase in the number of RASFF notifications regarding the failure to declare the presence of milk and its traces in food may be related to the enforcement of Regulation (EU)

1169/2011 [50] and, consequently, the increase in controls for allergen presence (Table 1). Alerts of this kind were reported for cocoa products, coffee drinks, and chocolate produced in Germany (Table 2).

Coffee, tea, cocoa, and chocolate are products very eagerly consumed not only due to their sensory properties but also because of their impact on the human body [51–53]. Many consumers add milk to coffee and tea, even though some studies show that this addition has a negative impact on these drinks' nutritional and functional values [54,55]. Adding milk to coffee and tea may be dangerous for many consumers because milk, especially cow's milk, is one of the most common food allergens [56]. It is commonly believed that avoiding allergens in one's diet is the basis for the treatment of food allergies. Therefore, the primary task of surveillance and control services is to analyse the presence of undeclared allergens on food labels through European Union RASFF notifications to provide information for a risk assessment [57]. Milk allergy has been on the rise in Europe since 2000, and the strict dietary avoidance of allergens has been widely recognised as a key treatment intervention for food allergies. This increase in the presence of allergens such as milk and its traces is particularly dangerous for children, who are the main consumers of products such as cocoa drinks, products containing cocoa, and chocolate. Therefore, it is most important to check food labels for the presence of food allergens in their composition [58]. Recently, we have observed an innovative trend in which consumers choose drinks containing various plant milks to avoid the risk of consuming a drink containing cow's milk [59].

Illegal food imports are a serious problem, constituting a large share of the food fraud and adulteration notifications on the RASFF platform [31]. The data show that attempted illegal imports and illegal imports accounted for over 400 of the incidents reported on RASFF between 2005 and 2020 (Table 1). The products detained at the EU border were vegetables and fruits such as beans, nuts, and seeds from Nigeria and nuts and seeds (peanuts) from Ghana, alongside fish and fish products from Bangladesh (Table 2). The rejections of the latter products most often occur due to microbiological and biological contamination [60], and it can be assumed that fish subject to these illegal import attempts were of a low quality or were contaminated. In the case of import from third countries, certificates may be forged due to low control standards [61]. According to Kareem et al.'s research [62], the main reason for EU border rejections of food from African countries is exceeding the limits for microbiological contamination, weak and insufficient control, adulteration, and fraudulent practices. They show that Africa lacks a strong regulatory institution in the area of food quality.

Another food additive often used in food processing is benzoic acid (E 210), which, together with sorbic acid (E 200) and their salts (E 211–213 and E 202–203), is used to inhibit mould and yeast growth and bacterial multiplication in foods such as long-shelf-life bread, fish products, juices, and drinks. The use of benzoic acid and its salts as food additives may increase hypersensitivity and/or cause skin reactions in sensitive people. Anaphylaxis and urticaria have also been observed following exposure below the ADI. Benzoic acid in large doses may lead to acid–base disturbances and disrupt the metabolism [63]. The EFSA has set the acceptable daily intake of benzoic acid and benzoates at 5 mg/kg body weight [64]. However, it should be remembered that benzoic acid and its salts may naturally occur in some fruits, such as raspberries and cranberries, spices (cinnamon, anise, nutmeg, etc.) and mushrooms [65,66]. In 2003 and 2006–2013, benzoic acid was reported on the RASFF platform under "food additives and flavourings" category for its excessive content and unauthorised or undeclared use (Table 1) in beverages, including energy drinks and soft drinks from the USA and Nigeria (Table 2).

The hazards reported on RASFF also include carbon monoxide (CO) use in food, with numerous cases recorded in 2003–2006 and 2010–2013 in fish and fish products (tuna) (Table 1) originating from Spain, The Netherlands, and Indonesia (Table 2). Globalisation, food transport over long distances, and the need to ensure the highest quality of food during storage have resulted in the development of methods such as modified-atmosphere food packaging (MAP), which employs inert gases. However, the use of CO in meat,

fish, and seafood packaging is controversial and is prohibited in most countries due to its potential toxic effects [67]. The USA, Canada, Australia, and New Zealand accept CO use, while EU member states prohibit it in food processing. The main disadvantage of using CO_2 for packaging meat and fish is the fear of masking microbiological risk by creating a persistent, long-lasting, light-red colour. When using CO in MAP meat and fish products, packaging should be properly labelled with reliable times, ensuring a maximum shelf life (use-by date) [67,68]. Those in favour of allowing CO as a packaging gas in the EU point to benefits such as European processors being able to export CO-pre-treated meat to countries where CO is allowed, potentially increasing exports and profits [68]. Studies have also shown that low CO doses prolong fruit quality after harvest [69].

Irregularities related to defective labelling were frequently reported in the RASFF (Table 1), including cereal and confectionery products from Poland and Germany (Table 2). The presence of gluten not being indicated on a product's packaging may be dangerous to the life and health of consumers with coeliac disease. Therefore, the obligation to place this information on packaging, including warnings about the possibility of even traces of gluten, is specified in Regulation (EU) 1169/2011 on the provision of food information to consumers [50]. Unfortunately, the lack of labelling of gluten in food products is a very common phenomenon, confirmed by Guennouni et al., who found the presence of gluten even in products declared to be gluten-free. For this reason, it is necessary to implement preventive measures to reduce gluten contamination, ensuring safe gluten-free food for people with coeliac disease [70].

Increasing globalisation and civilisation, lifestyle, and consumer behaviour changes are affecting diets. Changes in eating behaviour are also influenced by the development of tourism and migration [71]. For instance, we are observing increased interest in the cuisine of other countries, leading to a need to obtain ingredients, sometimes from very distant parts of the world, to prepare dishes. These ingredients include algae and nori (*Porphyra*), wakame (*Undaria*), and kombu (*Laminaria*) seaweeds, popular food ingredients in Asian countries such as Taiwan, China, Japan, and Korea. Seaweed is a well-known food source that is high in iodine. Although iodine is necessary for the proper functioning of the thyroid gland, its excess or deficiency is harmful to health. In recent years, food recall reports for excessive iodine content in Australia, Ireland, Singapore, and the European Union have raised concerns internationally, particularly for seaweed and its products [72].

This has been confirmed by numerous RASFF hazard notifications, including information on high iodine levels or failure to declare its presence in algae and seaweed from China, the Republic of Korea, Japan, The Netherlands, and France (Tables 1 and 2). The recommended iodine intake for adults is 150 µg/day [73], with an upper tolerable intake level established by the Scientific Committee on Food (SCF) of 600 µg/day [74]. Both low and high iodine intakes may result in insufficient thyroid hormone production and negative health effects [70]. Studies have shown that the iodine content in algae and seaweed is influenced by many factors, such as the organism species, the water temperature, the depth of the algae in seawater, and the seawater iodine content [75–77]. Algae and seaweeds should, therefore, be subject to special control and supervision. It has also been demonstrated that it is possible to reduce the iodine content in algae and seaweed using heat treatment [78].

4.2. Link Maps, Further Research Directions, and Study Strengths and Limitations

The VOSviewer 1.6.20 analysis results are presented in Figures 3 and 4 (network and overlay visualisation, respectively), showing maps of the association of the keywords "food", "fraud", or "adulteration" with others given by the authors of scientific works. Both maps consist of 305 keywords (elements). In Figure 3, six clusters are visible (each in a different colour), while Figure 4 illustrates the links between the keywords and the year of publication (the words included in the most recent publications, i.e., from 2018 onwards, are marked in yellow).

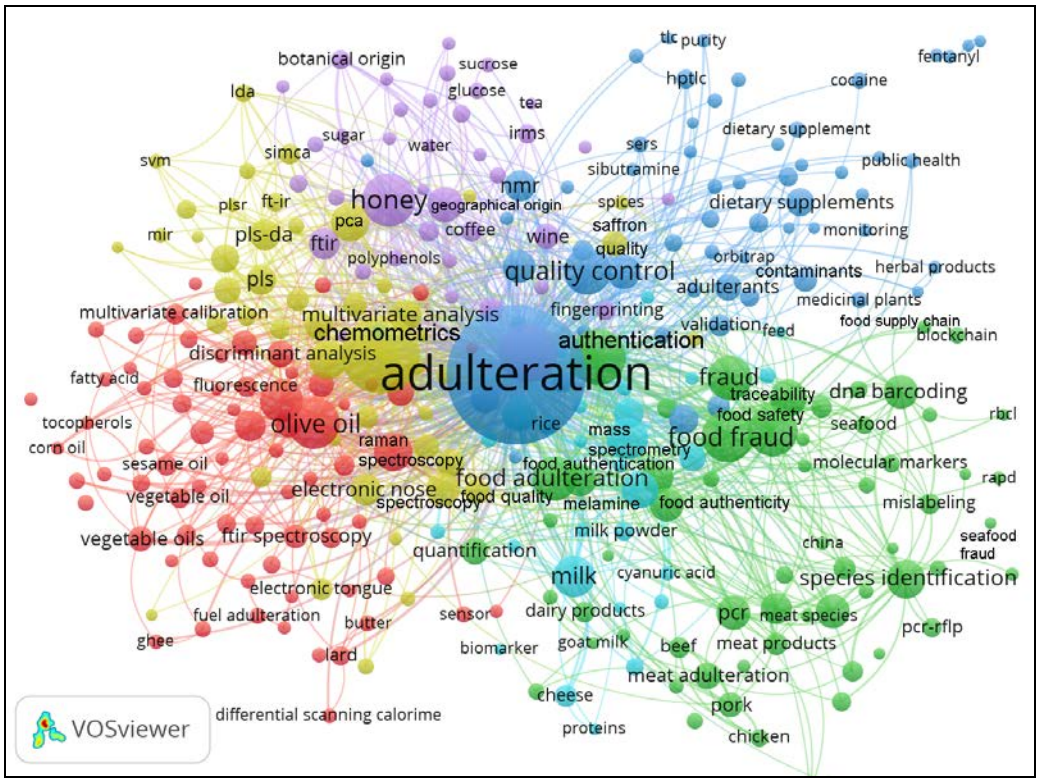


Figure 3. Network visualisation of the links between the keywords "food", "fraud", and "adulteration", and others.

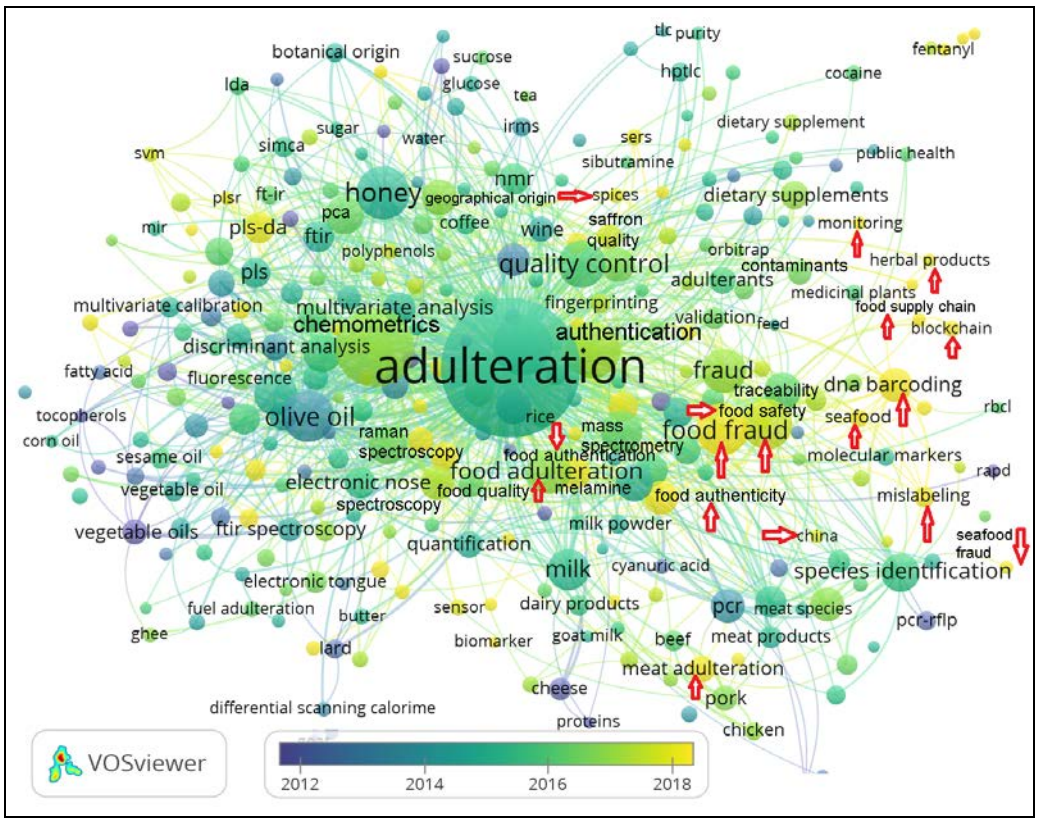


Figure 4. The overlay visualisation of the links between the keywords "food", "fraud", or "adulteration", and others.

The elements in each Figure 3 cluster are more similar to each other (in terms of number of links) than to those in other clusters, but all clusters are connected. It is noteworthy that the larger an element is, the greater the number of times that it is linked to other elements, meaning that the authors were more likely to indicate a given keyword alongside others. The largest element ("adulteration" in the dark-blue cluster) is located in the middle of the map and other visible elements of this cluster include "quality control", "quality", "dietary supplements", and "contaminants". In the olive cluster, "chemometrics" is the most important element, and it also contains "multivariate analysis", "spectroscopy", and "food quality". In the middle of the other clusters are food products, i.e., "olive oil" (red), "honey" (purple), and "milk" (light blue). However, the largest number of distinct elements directly or indirectly related to this research are in the green cluster: "food fraud", "fraud", "food adulteration", "food safety", "food authenticity", "food authentication", "authentication", "traceability", and "species identification".

The relevance of the study undertaken is confirmed by the map shown in Figure 4, where the previously mentioned issues have just been the subject of most interest to researchers in recent years (yellow elements are additionally marked with red arrows).

Indeed, the following issues are related to this study's topic, starting with the largest elements: "food fraud", "food adulteration", "food safety", "food authenticity", "food authentication", "mislabelling", "monitoring", "food supply chain", and "blockchain". The authors also highlighted specific product groups—herbs, spices, meat, seafood—and one country (China). This indirectly corresponds with the research conducted (a significant number of border rejections), as it can be concluded that the longer the food supply chain, the more vulnerable the consumer is to fraud or adulteration. It should also be noted that DNA barcoding has become the subject of recent research, and, while taking such measures increases consumer safety, it also raises food prices.

The strength of our research results is the application of a cross-sectional and multidimensional approach to RASFF food fraud and adulteration notifications over a long period of time (2000–2021). However, this research has some limitations related to both the available data and the methods used. As the data in the official RASFF database are only available from 2020 onwards, data from the restored database (up to and including 2021) were used for this study. There were sometimes typos in the acquired data, and, in addition, the same products or hazards appeared under different names, making it necessary to align their names.

Another limitation was due to the cluster analysis conducted in Statistica 13.3: although the result (Figure 2) contains most RASFF notifications, their number had to be limited to about 30 to maintain chart readability. The lack of continuity of the automatically generated legend scale and arranging the years according to the number of notifications (rather than sequentially) can also be seen in this chart, making it difficult to interpret the results. In turn, the maps created in VOSviewer 1.6.20 were missing the names of some elements and, therefore, had to be manually overwritten.

The data from the official RASFF database (i.e., for the years 2022–2023) could be used in future studies after combining them with the data from the restored RASFF database (i.e., up to and including 2021). However, it should be borne in mind that the data from these two databases have different structures, so combining them would cause some difficulties. In an extended study, an analysis could also be carried out for other variables such as notification basis, distribution status, and action taken. However, it should also be noted that part of the data on food fraud and adulteration are currently gathered in a different network, the EU Agri-Food Fraud Network (FFN), to which only member states' supervisory authorities have access [79].

Regarding the improvement of the official RASFF database, the European Commission should restore access to historical data. Currently, it only contains data from 2020 to 2023 (four years), so analyses based on these data cannot show long-term notification trends. In addition, hazard category information should also be added to the exported files, while

it can currently only be obtained indirectly by indicating the relevant category before exporting the data.

5. Conclusions

In the Rapid Alert System for Food and Feed (RASFF), fraud and adulteration notifications represented 18.7% of all notifications reported between 2000 and 2021. Of greatest concern are hazards related to composition and novel foods in food supplements and fortified foods, sulphites in fruits and vegetables, colours in cereals and bakery products or Sudan dye in herbs and spices, and also problems with health certificates in various product categories. Dietetic foods, food supplements, and fortified foods were mainly mentioned in alerts and information notifications, meaning that they were already on the internal European market, while hazards in other products were mainly reported after border rejection and originated from Asia (Turkey, Uzbekistan, and India) and Africa (Ghana and Nigeria).

Fraud and adulteration have economic, image, ethical, and marketing implications. However, for consumers who are sensitive to allergenic substances or toxic compounds, the health effects of food adulteration are the most dangerous. The results of this study indicate activity of the European food control authorities whilst pointing out the need for closer cooperation between EU and non-EU bodies.

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References

1. Borchers, A.T.; Hagie, F.; Keen, C.L.; Gershwin, M.E. The history and contemporary challenges of the US Food and Drug Administration. *Clin. Ther.* **2007**, *29*, 1–16. [CrossRef] [PubMed]
2. Stanziani, A. Negotiating Innovation in a Market Economy: Foodstuffs and Beverages Adulteration in Nineteenth-Century France. *Enter. Soc.* **2007**, *8*, 375–412. [CrossRef]
3. Dayan, A.D.; Dayan, J.D. Accum and food adulteration: A forgotten bicentennial. *Toxicol. Res. Appl.* **2021**, *5*, 23978473211033034. [CrossRef]
4. Spink, J.; Moyer, D.C. Defining the Public Health Threat of Food Fraud. *J. Food Sci.* **2011**, *76*, 157–163. [CrossRef] [PubMed]
5. Charlebois, S.; Schwab, A.; Henn, R.; Huck, C.W. Food fraud: An exploratory study for measuring consumer perception towards mislabelled food products and influence on self-authentication intentions. *Trends Food Sci. Technol.* **2016**, *50*, 211–218. [CrossRef]
6. Manning, L.; Soon, J.M. Food Safety, Food Fraud, and Food Defense: A Fast Evolving Literature. *J. Food Sci.* **2016**, *81*, 823–834. [CrossRef] [PubMed]
7. Spink, J.; Ortega, D.L.; Chen, C.; Wu, F. Food fraud prevention shifts the food risk focus to vulnerability. *Trends Food Sci. Technol.* **2017**, *62*, 215–220. [CrossRef]
8. Kowalska, A. The study of the intersection between food fraud /adulteration and authenticity. *Acta Univ. Agric. Silvic. Mendel. Brun.* **2018**, *66*, 1275–1286. [CrossRef]
9. *ISO 22000*; 2018 Food Safety Management Systems. Requirements for Any Organization in the Food Chain. International Organization for Standardization (ISO): Geneva, Switzerland, 2018.
10. European Parliament Council. Regulation (EC) 178/2002 of the European Parliament and of the Council of 28 January 2002 Laying Down the General Principles and Requirements of Food Law, Establishing the European Food Safety Authority and Laying Down Procedures in Matters of Food Safety. *Off. J. L* **2002**, *31*, 1–24.

11. Śmiechowska, M. Zapewnienie autentyczności i wiarygodności produktom regionalnym i tradycyjnym. *Rocz. Nauk. Stowarzyszenia Ekon. Rol. I Agrobiznesu* **2014**, *16*, 282–287.
12. Popping, B.; Buck, N.; Bánáti, D.; Brereton, P.; Gendel, S.; Hristozova, N.; Murinha Chaves, S.; Saner, S.; Spink, J.; Willis, C.; et al. Food inauthenticity: Authority activities, guidance for food operators, and mitigation tools. *Compr. Rev. Food Sci. Food Saf.* **2022**, *21*, 4776–4811. [CrossRef] [PubMed]
13. Bernard, A.; Broeckaert, F.; De Poorter, G.; De Cock, A.; Hermans, C.; Saegerman, C.; Houins, G. The Belgian PCB/dioxin incident: Analysis of the food chain contamination and health risk evaluation. *Environ. Res.* **2002**, *88*, 1–18. [CrossRef] [PubMed]
14. Brooks, S.; Elliott, C.T.; Spence, M.; Walsh, C.; Dean, M. Four years post-horsegate: An update of measures and actions put in place following the horsemeat incident of 2013. Nature partner journals. *Sci. Food* **2017**, *1*, 5.
15. Afonso, A.; Garcia Matas, R.; Gkrintzali, G.; Maggiore, A.; Merten, C.; Rortais, A.; Robinson, T. EFSA's activities on emerging risks in 2019. *EFSA Support. Publ.* **2020**, *17*, E1924.
16. European Commission. *Farm to Fork Strategy. For a Fair, Healthy and Environmentally-Friendly Food System*; European Union: Brussels, Belgium, 2020.
17. Rapid Alert System for Food and Feed (RASFF). Available online: https://food.ec.europa.eu/safety/rasff_en (accessed on 3 November 2023).
18. Dataset. RASFF—Rapid Alert System for Food and Feed. Available online: https://data.europa.eu/data/datasets/restored_rasff?locale=en (accessed on 15 February 2023).
19. RASFF Window. Available online: https://webgate.ec.europa.eu/rasff-window/screen/search (accessed on 3 November 2023).
20. TIBCO Statistica® User's Guide. Available online: https://docs.tibco.com/pub/stat/14.0.0/doc/html/UsersGuide/ (accessed on 13 January 2023).
21. Web of Science. Available online: https://www.webofscience.com/wos/woscc/basic-search (accessed on 11 July 2024).
22. Van Eck, N.J.; Waltman, N.R. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* **2010**, *84*, 523–538. [CrossRef] [PubMed]
23. Bukar, U.A.; Sayeed, M.S.; Razak, S.F.A.; Yogarayan, S.; Amodu, O.A.; Mahmood, R.A.R. A method for analyzing text using VOSviewer. *MethodsX* **2023**, *11*, 102339. [CrossRef] [PubMed]
24. Danezis, G.P.; Tsagkaris, A.S.; Brusic, V.; Georgiou, C.A. Food authentication: State of the art and prospects. *Curr. Opin. Food Sci.* **2016**, *10*, 22–31. [CrossRef]
25. Ulberth, F. Tools to combat food fraud—A gap analysis. *Food Chem.* **2020**, *330*, 127044. [CrossRef] [PubMed]
26. European Union. *RASFF—The Rapid Alert System for Food and Feed—2013 Annual Report*; Publications Office of the European Union: Luxembourg, 2014.
27. European Union. *RASFF—The Rapid Alert System for Food and Feed—2017 Annual Report*; Publications Office of the European Union: Luxembourg, 2018.
28. European Union. *RASFF—The Rapid Alert System for Food and Feed—2018 Annual Report*; Publications Office of the European Union: Luxembourg, 2019.
29. European Union. *RASFF—The Rapid Alert System for Food and Feed—Annual Report 2019*; Publications Office of the European Union: Luxembourg, 2020.
30. Owolabi, I.O.; Karoonuthaisiri, N.; Elliott, C.T.; Petchkongkaew, A. A 10-year analysis of RASFF notifications for mycotoxins in nuts: Trend in key mycotoxins and impacted countries. *Food Res. Int.* **2023**, *172*, 112915. [CrossRef]
31. Owolabi, I.O.; Olayinka, J.A. Incidence of fraud and adulterations in ASEAN food/feed exports: A 20-year analysis of RASFF's notifications. *PLoS ONE* **2021**, *16*, e0259298. [CrossRef]
32. Gziut, T.; Thomas, S.H.L. International trends in systemic human exposures to 2,4 dinitrophenol reported to poisons centres. *Clin. Toxicol.* **2020**, *60*, 628–631. [CrossRef] [PubMed]
33. Kotta, S.; Ansami, S.H.; Ali, J. Exploring scientifically proven herbal aphrodisiacs. *Pharmacogn. Rev.* **2013**, *7*, 1.
34. European Commission. Commission Regulation (EU) 2019/650 of 24 April 2019 amending Annex III to Regulation (EC) No 1925/2006 of the European Parliament and of the Council as regards Yohimbe (*Pausinystalia yohimbe* (K. Schum) Pierre ex Beille). *Off. J. L* **2019**, *110*, 21–22.
35. Neis, V.B.; Rosa, P.B.; Olescowicz, G.; Rodrigues, A.L.S. Therapeutic potential of agmatine for CNS disorders. *Neurochem. Int.* **2017**, *108*, 318–331. [CrossRef] [PubMed]
36. European Union. *2021 Annual Report: Alert and Cooperation Network*; Publications Office of the European Union: Luxembourg, 2022.
37. European Union. *2022 Annual Report: Alert and Cooperation Network*; Publications Office of the European Union: Luxembourg, 2023.
38. Mwale, M.M. *Health Risk of Food Additives: Recent Developments and Trends in the Food Sector*; InTech Open: Rijeka, Croatia, 2023. [CrossRef]
39. Bonerba, E.; Ceci, E.; Bozzo, G.; Di Pinto, A.; Tantillo, G. Analysis of the sulphite content in shrimps and prawns. *Ital. J. Food Saf.* **2013**, *2*, e18. [CrossRef]
40. Gupta, M.K.; Basavaraj, G.V. Sulphites in food & drinks in asthmatic adults & children: What we need to know. *Ind. J. Allergy Asthma Immunol.* **2021**, *35*, 43–47.
41. Vally, H.; La Misso, N. Adverse reactions to the sulphite additives. *Gastroenterol. Hepatol. Bed Bench* **2012**, *5*, 16–23. [PubMed]

42. Hajri, Z.; Chigr, M.; Oussama, A.; Kzaiber, F.; Boutoial, K. Dietary exposure assessment to sulfites (SO_2) in the Moroccan adult population. *Food Res.* **2023**, *7*, 1–10. [CrossRef] [PubMed]
43. Joint FAO/WHO Expert Committee on Food Additives (JECFA). *Toxicological Evaluation of Certain Food Additives with a Review of General Principles and of Specifications: 17th Report of the JECFA*; WHO: Geneva, Switzerland, 1974.
44. European Commission. Commission Decision 2003/460/EC of 20 June 2003 on emergency measures regarding hot chilli products. *Off. J. L* **2003**, *154*, 114–115.
45. European Commission. Commission implementing Regulation (EU) 2019/1793 of 22 October 2019 on the temporary increase of official controls and emergency measures governing the entry into the Union of certain goods from certain third countries implementing Regulations (EU) 2017/625 and (EC) No 178/2002 of the European Parliament and of the Council and repealing Commission Regulations (EC) No 669/2009, (EU) No 884/2014, (EU) 2015/175, (EU) 2017/186 and (EU) 2018/1660. *Off. J. L* **2019**, *277*, 89–129.
46. Barciela, P.; Perez-Vazquez, A.; Prieto, M.A. Azo dyes in the food industry: Features, classification, toxicity, alternatives, and regulation. *Food Chem. Toxicol.* **2023**, *178*, 113935. [CrossRef]
47. Miller, M.D.; Steinmaus, C.; Golub, M.S.; Castorina, R.; Thilakartne, R.; Bradman, A.; Marty, M.A. Potential impacts of synthetic food dyes on activity and attention in children: A review of the human and animal evidence. *Environ. Health* **2022**, *21*, 45. [CrossRef]
48. Śmiechowska, M.; Newerli-Guz, J.; Skotnicka, M. Spices and Seasoning Mixes in European Union—Innovations and Ensuring Safety. *Foods* **2021**, *10*, 2289. [CrossRef] [PubMed]
49. Newerli-Guz, J.; Śmiechowska, M. Health Benefits' and Risks of Consuming Spices on the Example of Black Pepper and Cinnamon. *Foods* **2022**, *11*, 2746. [CrossRef]
50. European Parliament Council. Regulation (EU) 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004. *Off. J. L* **2011**, *304*, 18–63.
51. Poole, R.; Kennedy, O.J.; Roderick, P.; Fallowfield, J.A.; Hayes, P.C.; Parkes, J. Coffee consumption and health: Umbrella review of meta-analyses of multiple health outcomes. *Brit Med. J.* **2017**, *359*, j5024. [CrossRef]
52. Tang, G.-Y.; Meng, X.; Gan, R.-Y.; Zhao, C.-N.; Liu, Q.; Feng, Y.-B.; Li, S.; Wei, X.-L.; Atanasov, A.G.; Corke, H.; et al. Health Functions and Related Molecular Mechanisms of Tea Components: An Update Review. *Int. J. Mol. Sci.* **2019**, *20*, 6196. [CrossRef]
53. Tan, T.Y.C.; Lim, X.Y.; Yeo, J.H.H.; Lee, S.W.H.; Lai, N.M. The Health Effects of Chocolate and Cocoa: A Systematic Review. *Nutrients* **2021**, *13*, 2909. [CrossRef]
54. Rashidinejad, A.; Birch, E.J.; San-Waterhouse, D.; Everett, D.W. Addition of milk to tea infusions: Helpful or harmful? Evidence from in vitro and in vivo studies on antioxidant properties—A review. *Crit. Rev. Food Sci. Nutr.* **2017**, *57*, 3188–3196. [CrossRef] [PubMed]
55. Rashidinejad, A.; Tarhan, O.; Rezaei, A.; Capanoglu, E.; Boostani, S.; Khoshnoudi-Nia, S.; Samborska, K.; Garavand, F.; Shaddel, R.; Akbari-Alavijeh, S.; et al. Addition of milk to coffee beverages; the effect on functional, nutritional, and sensorial properties. *Crit. Rev. Food Sci.* **2021**, *62*, 6132–6152. [CrossRef] [PubMed]
56. Giannetti, A.; Vespasiani, G.T.; Ricci, G.; Miniaci, A.; di Palmo, E.; Pession, A. Cow's Milk Protein Allergy as a Model of Food Allergies. *Nutrients* **2021**, *13*, 1525. [CrossRef]
57. Pádua, I.; Moreira, A.; Moreira, P.; Melo de Vasconcelos, F.; Barros, R. Impact of the regulation (EU) 1169/2011: Allergen-related recalls in the rapid alert system for food and feed (RASFF) portal. *Food Control* **2019**, *98*, 389–398. [CrossRef]
58. Martínez-Pineda, M.; Yagüe-Ruiz, C. The Risk of Undeclared Allergens on Food Labels for Pediatric Patients in the European Union. *Nutrients* **2022**, *14*, 1571. [CrossRef]
59. Gorman, M.; Knowles, S.; Falkeisen, A.; Barker, S.; Moss, R.; McSweeney, M.B. Consumer Perception of Milk and Plant-Based Alternatives Added to Coffee. *Beverages* **2021**, *7*, 80. [CrossRef]
60. Pigłowski, M. Hazards in Seafood Notified in the Rapid Alert System for Food and Feed (RASFF) in 1996–2020. *Water* **2023**, *15*, 548. [CrossRef]
61. Giannakas, K.; Yiannaka, A. Food Fraud: Causes, Consequences, and Deterrence Strategies. *Annu. Rev. Resour. Econ.* **2023**, *15*, 85–104. [CrossRef]
62. Kareem, F.O.; Martinez-Zarzoso, I.; Brümmer, B. What Drives Africa's Inability to Comply with EU Standards? Insights from Africa's Institution and Trade Facilitation Measures. *Eur. J. Dev. Res.* **2023**, *35*, 938–973. [CrossRef]
63. Vojvodić, S.; Srdjenović Čonić, B.; Torović, L. Benzoates and in situ formed benzene in food supplements and risk assessment. *Food Addit. Contam. B* **2003**, *16*, 321–331. [CrossRef]
64. European Food Safety Agency (EFSA). Scientific opinion on the re-evaluation of benzoic acid (E 210), sodium benzoate (E 211), potassium benzoate (E 212) and calcium benzoate (E 213) as food additives. *EFSA J.* **2016**, *14*, 4433.
65. Del Olmo, A.; Calzada, J.; Nuñez, M. Benzoic acid and its derivatives as naturally occurring compounds in foods and as additives: Uses, exposure, and controversy. *Crit. Rev. Food Sci.* **2017**, *57*, 3084–3103. [CrossRef] [PubMed]
66. Yun, S.S.; Kim, J.; Lee, S.J.; So, J.S.; Lee, M.Y.; Lee, G.; Lim, H.S.; Kim, M. Naturally occurring benzoic, sorbic, and propionic acid in vegetables. *Food Addit. Contam. B* **2019**, *12*, 167–174. [CrossRef] [PubMed]

67. Djenane, D.; Roncalés, P. Carbon Monoxide in Meat and Fish Packaging: Advantages and Limits. *Foods* **2018**, *7*, 12. [CrossRef]
68. Van Rooyen, A.P.; O'Connor, D.I. The application of carbon monoxide in meat packaging needs to be re-evaluated within the EU: An overview. *Meat Sci.* **2017**, *132*, 179–188. [CrossRef] [PubMed]
69. Zhang, S.; Li, Y.; Pei, F. Carbon Monoxide Fumigation Improved the Quality, Nutrients, and Antioxidant Activities of Postharvest Peach. *Int. J. Food Sci. Technol.* **2014**, *2014*, 834150. [CrossRef] [PubMed]
70. Guennouni, M.; Admou, B.; El Khoudri, N.; Bourrhouat, A.; Zogaam, L.G.; Elmoumou, L.; Hilali, A. Gluten contamination in labelled gluten-free, naturally gluten-free and meals in food services in low-, middle- and high-income countries: A systematic review and meta-analysis. *Br. J. Nutr.* **2022**, *127*, 1528–1542. [CrossRef] [PubMed]
71. Hanus, G. The impact of globalization on the food behaviour of consumers—Literature and research review. In Proceedings of the CBU International Conference on Innovations in Science and Education, Prague, Czech Republic, 21–23 March 2018.
72. Yeh, T.S.; Hung, N.H.; Lin, T.C. Analysis of iodine content in seaweed by GC-ECD and estimation of iodine intake. *J. Food Drug Anal.* **2014**, *22*, 189–196. [CrossRef]
73. World Health Organisation (WHO); United Nations Children's Fund and International Council for Control of Iodine Deficienc Disorders. *Assessment of Iodine Deficiency Disorders and Monitoring their Elimination: A Guide for Programme Managers*; WHO: Geneva, Switzerland, 2007.
74. European Commission (EC). *Opinion of the Scientific Committee on Food on the Tolerable Upper Intake Level of Iodine*; SCF/CS/NUT/UPPLEV/26 Final, 7.10.2002; European Commission: Brussels, Belgium, 2002.
75. Blikra, M.J.; Henjum, S.; Aare, I. Iodine from brown algae in human nutrition, with an emphasis on bioaccessibility, bioavailability, chemistry, and effects of processing: A systematic review. *Compr. Rev. Food Sci. Food Saf.* **2022**, *21*, 1517–1536. [CrossRef] [PubMed]
76. Carrano, M.W.; Yarimizu, K.; Gonzales, J.L.; Cruz-López, L.; Edwards, M.S.; Tymon, T.M.; Küpper, F.C.; Carrano, C.J. The influence of marine algae on iodine speciation in the coastal ocean. *Algae* **2020**, *35*, 167–176. [CrossRef]
77. Teas, J.; Pino, S.; Critchley, A.; Braverman, L.E. Variability of Iodine Content in Common Commercially Available Edible Seaweeds. *Thyroid* **2004**, *14*, 836–841. [CrossRef] [PubMed]
78. Krook, J.L.; Duinker, A.; Larssen, W.E.; Birkeland, I.M.; Skeie, S.; Horn, S.J.; Stévant, P. Approaches for reducing the iodine content of the brown seaweed *Saccharina latissima*—Effects on sensory properties. *J. Appl. Phycol.* **2023**, *36*, 783–796. [CrossRef]
79. The Alert and Cooperation Network. Available online: https://food.ec.europa.eu/safety/acn_en (accessed on 11 July 2024).

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