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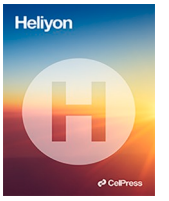

Analysis of data from the rapid alert system for food and feed for the country-of-origin Slovakia for 2002–2020

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A B S T R A C T

The Rapid Alert System for Food and Feed (RASFF) plays a pivotal role in regulating food safety in the European Union by enabling the competent authorities in each Member State to issue warnings for removing unsafe or illegal items from the market. This article undertakes a comprehensive analysis of RASFF data on Slovak food from 2002 to 2020, to investigate the trends in notifications, actions executed, hazard categories, and product categories within the food industry. Our scrutiny of the RASFF data revealed fluctuations in the counts of alerts and information notifications across years, indicating periods of heightened hazard detection and enhanced transparency within the system. Various measures, including destruction, recall, notification, and prohibition, were employed to address these hazards and ensure the safety and compliance of food products. The hazard categories exhibited sporadic patterns, underscoring the necessity for ongoing surveillance and regulatory interventions. Specific product categories, such as dietetic foods, food supplements, and fortified foods, registered higher incidences of hazards in specific years, implying the need for intensified safety precautions. These findings highlight the importance of sustained efforts in maintaining food safety and managing risks within the industry.

1. Introduction

The increasing complexity and globalization of our food supply chain have introduced new challenges for ensuring the safety and quality of food products. To tackle these issues, food producers and authorities are tasked with managing a wide array of potential food contaminant hazards, by Regulation (EC) No. 852/2004 and implementing a minimum HACCP system. In this context, the Rapid Alert System for Food and Feed (RASFF) has proven to be an instrumental tool, with over 30 years of operation and significantly increased efficacy [1]. A rapid alert system for food and feed safeguards food safety and public health. It offers a multitude of benefits:

Early Warning of Safety Hazards: The system facilitates early detection and notification of safety hazards in food and feed products, enabling swift action to prevent the distribution and consumption of contaminated or unsafe items, thus reducing foodborne illnesses and health-related issues.

Timely Recall and Withdrawal of Products: Upon identification of a safety issue, the system expedites the recall or withdrawal of

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the affected food and feed products from the market. This immediate response helps prevent further exposure to potentially hazardous products and minimizes public health impacts [2].

International Coordination and Collaboration: The system fosters enhanced international coordination and collaboration among countries and regulatory authorities. Prompt information sharing on safety hazards and product recalls enables countries to take protective measures, prevent the cross-border spread of contaminated products, and facilitate more effective traceability and risk management.

Improved Consumer Confidence: The presence of a robust rapid alert system bolsters consumer confidence in the safety of food and feed products. Seeing timely actions taken to address safety issues assures consumers about their purchases, leading to increased trust in regulatory systems and food supply chains [3].

Prevention of Economic Losses: The system assists in quickly identifying and containing safety hazards, thereby minimizing economic losses linked to food and feed recalls. Early intervention can forestall the widespread distribution of contaminated products, reducing the financial impact on businesses and mitigating potential long-term damage to reputations and market competitiveness [2].

RASFF is an online platform administered by the European Commission, designed to facilitate the exchange of information among food and feed control authorities in the European Union, as well as Norway, Liechtenstein, Iceland, and Switzerland. Its primary goal is to be a helpful tool for sharing information regarding the actions taken in response to significant risks identified in connection with food or feed products [4].

In Slovakia, the Ministry of Agriculture and Rural Development (MARD) and the Ministry of Health (MH) are responsible for planning and implementing official regulations throughout the food and feed supply chain. MARD oversees animal health, animal welfare, feeds, food safety, plant protection products, and plant health. At the same time, MH establishes the primary goals and priorities of state health policy in public health and manages domestic and international cooperation among central government agencies.

The regulatory framework for food control in Slovakia comprises the Food Act (No. 152/1995, Collection of Legislative Acts [5]), Act No. 355/2007 Coll. on Protection, Support, and Development of Public Health and Amendments and Supplements to Certain Acts [6], Act No. 39/2007 Coll. on Veterinary Care [7], Act No. 271/2005 Coll. on Feedingstuffs [8], and Act No. 405/2011 Coll. on Phytosanitary Care [9]. This comprehensive regulation empowers all authorities with controllable powers. The administrative division of Slovakia comprises 8 regions and 79 districts [10].

Operational control activities in the areas of food and feed safety, animal health, animal welfare, and plant health are executed by district control services. However, the number of these services does not always match the number of regions and districts in the country, as it is contingent on the internal structure of individual services. This study aimed to analyze RASFF notifications for food originating from Slovakia from 2002 to 2020, with particular attention given to the hazard category, food type, and measures taken.

2. Materials and methods

There are four types of E.U. RASFF notifications. According to the European Commission, these include “Alert notifications”, “Information notifications”, “Border rejections”, and “RASFF news” [2]. The terms “information for attention” and “information for follow-up” were used to identify two subgroups of information notifications in the EU legislation [11]. Information notifications are used when a food or feed hazard is identified but the product has not yet been distributed on the markets of an EU member state. In this instance, the risk posed by the hazard does not necessitate immediate action. Exports of food and feed that have been turned away at EU crossings due to dangers found in the product are the main focus of border rejections [12].

2.1. Data collection

A search in the EU Rapid Alert System for Food and Feed database (https://webgate.ec.europa.eu/rasff-window/portal/?event=searchForm&cleanSearch=1) retrieved the data used for this paper (accessed on May 30, 2021) [13]. The criteria used in the notification search were the following: notifying country, country of origin, type of notification, notification basis, hazard category, year of notification, and product category.

2.2. Statistical analysis

The RASFF database underwent initial processing utilizing Microsoft Excel (2016, Redmond, USA, Microsoft Corporation). Subsequently, data filtering was applied to extract information exclusively related to food or beverages originating from the Slovak Republic. Descriptive statistics, including frequency distribution of notifications on a year-by-year basis, were performed using SPSS for Windows (ver. 25, Chicago, SPSS Inc.), facilitating further analysis.

2.2.1. Temporal analysis of aggregate occurrence of reports from the rapid alert monitoring system

This study embarked on a comprehensive analysis of the temporal trajectory of aggregated reports, encompassing both alerts and pieces of information, sourced from the rapid alert monitoring system. Data were collated and transformed to exhibit a quarterly frequency. To ensure a consistent data series spanning 2004 to 2020, the analytical dataset deliberately excluded the year 2002, due to the data vacuum in 2003. Employing the Least Squares Linear Regression method, the study scrutinized the statistical significance of.

a) The trend component across the designated analytical timeline.

b) The quarterly seasonal component.

Furthermore, the ordinal independence and the constant variance of the extracted data were authenticated. A two-sided significance level of 5 % was predetermined for the statistical tests. All computational processes were executed using the GRETL econometric software.

The postulated estimation equation took the form: $count(t) = const + time(t) + q2(t) + q3(t) + q4(t) + \epsilon(t)$, where: t – Specified period, count - Report frequency within period t, const – Constant term, time - Time index, q2 to q4 - indicator variable for quarters 2 to 4 (quarter 1 is the reference), ϵ - A stochastic variable with uniform distribution. The employed model, dubbed Model 1: ARMAX, was predicated on observations from 2004:1 to 2020:4 ($T = 68$) and was estimated via least squares, specifically conditional Maximum Likelihood (ML), with "count" as the dependent variable.

2.2.2. Statistical relationship analysis between product and risk categories

This study embarked on an exploration of the statistical interconnections between product categories and associated risk categories. The research utilized the Correspondence Analysis technique, a method tailored for comparing and graphically representing the profiles of one nominal variable vis-à-vis the categories of another nominal category. To maintain robustness in the analytical findings, categories that manifested fewer than five times over the investigated period were omitted due to their limited reliability in statistical assessments. The analytical processes were executed using the STATSOFT STATISTICA software. The foundation data for this analysis were contingency tables. The outcome of the analysis consists of diagrams wherein the categories of the two variables are conjointly projected onto a mutual coordinate plane. This plane, within the diagrams, is demarcated by pairs of dimensions elucidating their interdependent relationships. The determination of the number of dimensions was predicated on cumulative explained variability, with a conscious effort to restrict their quantity from becoming excessively high. Specifically, for this study, three dimensions were deemed optimal, as elaborated in Table 2. Table 2 provides a decomposition of the variability within the complete dataset. In the first row, it is evident that the predominant three dimensions cumulatively account for approximately 63 % of the total variability. Subsequent dimensions incrementally contribute lesser to the elucidated variability; however, there is a swift increase in the quantity of two-dimensional diagrams. Based on this, we limit our focus to three dimensions.

3. Results and discussion

3.1. RASFF notification

The data presented in Fig. 1 demonstrates the annual distribution of RASFF notifications in the categories of alerts and information for the specified time range. The alerts category denotes identified hazards or risks associated with certain products. In contrast, the information category encompasses cases where relevant details were shared without an immediate identified risk. Upon examining the alerts category, we see that the notifications fluctuated yearly. Notably, 2007 experienced a significant spike in alerts, with 17 recorded cases, implying an increased identification of hazards during that period. Similarly, 2019 registered a relatively high count of 14 alerts, pointing to another year with considerable safety concerns. Conversely, 2009 saw the lowest number of alerts, with just a single recorded case, suggesting a year of lower identified hazards. When considering the information category, we observe irregularity in the number of notifications across the years. The most significant number of information notifications took place in 2011, with 22 instances, closely trailed by 2012, with 21 cases. These peaks in information sharing may signal periods of enhanced transparency and knowledge dissemination within the RASFF system. In contrast, 2002, 2009, and 2016 saw the least number of information notifications, with only two instances reported each year. In sum, the frequency of alerts and information within the RASFF system appears to fluctuate annually. Evaluating the patterns and trends observed in these notifications can help identify potential areas of concern, improve risk detection and communication, and gauge the overall efficacy of the RASFF system in ensuring food safety.

3.2. Notification basis

Several statistical observations can be made based on the given data in Fig. 2. Here is the revised review with some adjustments for clarity: The data shown in Fig. 2 provides insights into various aspects of the studied phenomena. The following observations can be made: Border control - consignment released: Consignments being released at border control were infrequent during the specified period, with only one instance reported in 2011. Border control - consignment detained: Detained consignments were relatively rare,

Table 1
Temporal evolution of the cumulative occurrence of reports (alerts + pieces of information).

Parameter	Coefficient	Std Error	Test statistic	p-value	Statistical significance (at 5 % level)	
const	3058	0,994	3076	0,002	yes	the average number of reports is approximately 3 per quarter
dq2	0,230	1076	0,214	0,831	no	The seasonal effect of Q2 is not significant ($p > 0.05$).
dq3	0,754	1076	0,701	0,484	no	The seasonal effect of Q3 is not significant ($p > 0.05$).
dq4	0,984	1077	0,913	0,361	no	The seasonal effect of Q4 is not significant ($p > 0.05$).
time	0,005	0,019	0,276	0,782	no	The time trend is not significant ($p > 0.05$).

Table 2
Variability decomposition table of the whole set.

	Singular value	Eigenvalue	% Inertia	% Cumulative Inertia	Chi-square
1	0,87	0,75	25,16	25,16	179,94
2	0,79	0,63	21,12	46,28	151,04
3	0,70	0,49	16,41	62,69	117,43
4	0,59	0,34	11,54	74,23	82,53
5	0,55	0,30	10,23	84,47	73,20
6	0,46	0,21	7,03	91,50	50,31
7	0,37	0,13	4,56	96,07	32,62
8	0,24	0,06	1,99	98,06	14,26
9	0,17	0,03	1,05	99,11	7,52
10	0,13	0,01	0,56	99,67	4,02
11	0,09	0,00	0,29	99,97	2,13
12	0,02	0,00	0,02	100,00	0,16

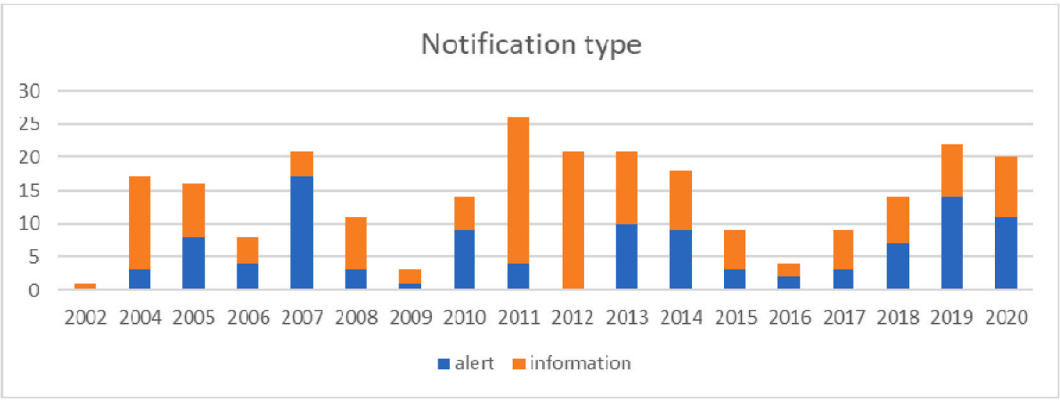

Fig. 1. Frequency Distribution of Notification Type Caption: Year-by-year distribution of hazard categories food from the country-of-origin Slovak Republic within the RASFF database, spanning the period from 2002 to 2022.

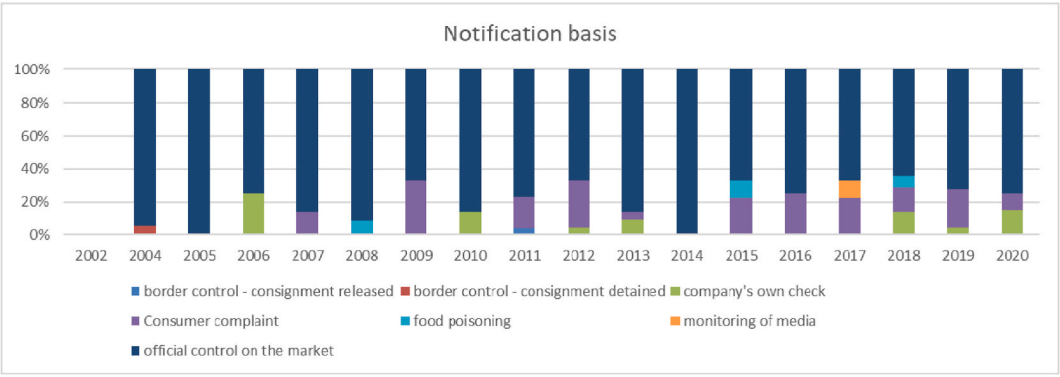

Fig. 2. Frequency Distribution of Notification Basis Caption: Year-by-year distribution of hazard categories food from the country-of-origin Slovak Republic within the RASFF database, spanning the period from 2002 to 2022.

as the single occurrence reported in 2004 indicated. Company's check: The number of occurrences varied annually, ranging from 0 to 3. This suggests that companies conducted their checks inconsistently or reported issues sporadically. Consumer complaint: The number of consumer complaints showed significant variation, with higher occurrences in 2011 (5), 2012 (6), and 2019 (5). This indicates that consumer complaints were more prevalent during those years. Food poisoning: The reported instances of food poisoning were few, with one occurrence each in 2008, 2015, and 2018. This suggests that food poisoning incidents were relatively uncommon or potentially underreported during the specified period. Monitoring of media: Media monitoring was not frequently utilized as a basis for notifications, with only one occurrence reported in 2017. Official control on the market: Official controls on the market were conducted several times throughout the years, with the highest numbers observed in 2011 (20), 2013 (18), and 2014 (18). This suggests that official controls on the market were more extensive during those years. Overall, the data indicates that consumer complaints and

official control on the market were the most frequently reported categories, while other categories such as border control issues, company checks, food poisoning, and media monitoring had fewer occurrences. The concept of companies conducting their checks as part of quality assurance processes has been widely studied. Many companies implement internal control mechanisms to ensure compliance with safety and quality standards. The sporadic nature of reported occurrences in this study may indicate varying levels of transparency and reporting practices among companies. Further research could investigate the effectiveness and consistency of company-led checks. Consumer complaints play a crucial role in identifying product or service-related issues and facilitating improvements. Extensive research has focused on analyzing the nature and causes of consumer complaints in various industries, including food, healthcare, and retail [14,15]. The higher occurrences of consumer complaints in certain years, as observed in this study, might be influenced by factors such as changes in consumer behavior, increased awareness, or shifts in regulatory requirements. Food poisoning incidents have received significant attention from researchers and regulatory agencies due to their potential health risks. Studies have examined the causes, sources, and preventive measures related to foodborne illnesses [16,17]. The relatively low number of reported occurrences in this study might be attributed to underreporting or other factors affecting the detection and reporting of food poisoning cases. The utilization of media monitoring as a basis for notifications has gained prominence in recent years. Research has explored the role of media in identifying and responding to public health issues and crises [18,19]. This study's limited occurrence of media monitoring notifications suggests that it might not have been extensively integrated into the notification processes during the specified period.

3.3. Action taken

The data analyzed in Fig. 3 includes various actions such as changing the product destination, destruction, informing authorities, informing consignors and recipients, taking no action, experiencing stock shortages, official detention, product recall or withdrawal, prohibition to trade (sales ban), public warning through press releases, and returning products to consignors. The analysis aims to provide insights into the trends and patterns of these actions over time. Notable observations include: The data shows different actions taken in response to identified hazards or incidents in the food industry. "Destruction" is the most frequently taken action, with occurrences in multiple years, indicating a proactive approach to eliminate unsafe or non-compliant products. "Product recall or withdrawal" is another significant action taken in response to hazards, demonstrating the importance of promptly removing potentially unsafe products from the market. "Informing authorities" and "informing recipient(s)" actions indicate the practice of notifying relevant parties about identified hazards for appropriate follow-up and investigation. "Official detention" and "seizure" actions reflect when authorities intervened to restrict or confiscate non-compliant or hazardous products. "Return to consignor" action suggests sending back non-compliant or unsafe products to the original sender for appropriate action. "No action taken" occurrences highlight instances where no specific action was documented or mentioned in the provided data. "No stock left" indicates situations where no further stock of a particular product was available due to actions taken, such as destruction or withdrawal. "Prohibition to trade - sales

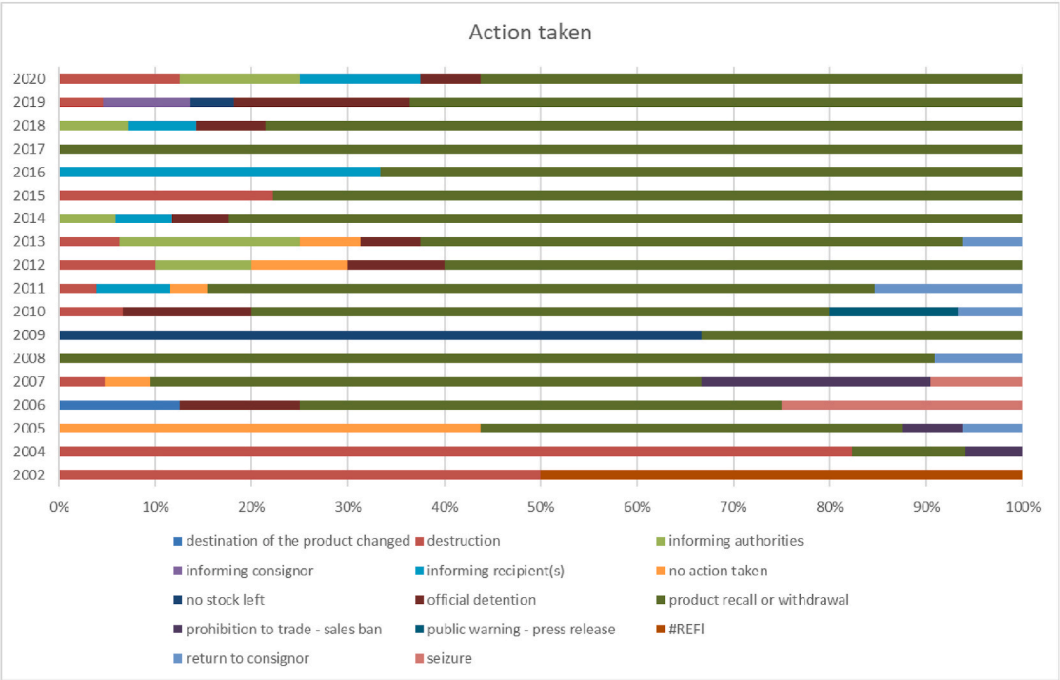

Fig. 3. Frequency Distribution of Action Taken Caption: Year-by-year distribution of hazard categories food from the country-of-origin Slovak Republic within the RASFF database, spanning the period from 2002 to 2022.

ban" suggests instances where specific products were prohibited from being sold or traded. “Public warning - press release” indicates the issuance of public warnings through press releases to inform consumers about potential risks associated with certain products. “Informing consignor” action specifically relates to notifying the original sender about identified hazards or non-compliance. Overall, the data suggests that a range of actions is taken to address hazards and ensure the safety and compliance of food products, including destruction, recall, notification, detention, and prohibition, among others. It’s important to note that the evaluation is based solely on the provided data and does not take into account any specific context or the effectiveness of the actions taken. The results of the analysis indicate that various actions are taken in response to identified hazards or incidents in the food industry. These actions aim to address the issues and ensure food products’ safety and compliance. Destruction: This action appears to be the most frequently taken in multiple years. It suggests a proactive approach to eliminating unsafe or non-compliant products from the market. Destruction is an important measure to prevent potentially harmful products from reaching consumers. Product recall or withdrawal: This action is another significant response to hazards, indicating the importance of promptly removing potentially unsafe products from the market. Product recalls or withdrawals are crucial for protecting consumers and mitigating risks associated with certain products. Informing authorities and recipients: Informing relevant authorities and recipients highlights the practice of notifying the appropriate parties about identified hazards. This allows for proper follow-up, investigation, and potential enforcement actions to address the issues effectively. Official detention and seizure: Instances of official detention and seizure suggest that authorities intervened to restrict or confiscate non-compliant or hazardous products. These actions indicate a regulatory response to mitigate risks and ensure compliance with food safety standards. Return to consignor: The action of returning products to the consignor indicates a practice of sending back non-compliant or unsafe products to the original sender for appropriate action. This can include further investigation, disposal, or other necessary measures to address the identified hazards. No action taken: The occurrences where no specific action was documented or mentioned in the provided data might indicate missing information or instances where no action was required or recorded. To understand the context fully, it is essential to consider the reasons behind the lack of documented actions. No stock left: This observation suggests situations where there was no further stock of a particular product due to actions taken, such as destruction or withdrawal. It implies that appropriate measures were taken to remove the affected products from circulation. Prohibition to trade - sales ban: The presence of this action indicates instances where specific products were prohibited from being sold or traded. This measure is likely taken to prevent further distribution or consumption of potentially hazardous products. Public warning - press release: The issuance of public warnings through press releases indicates an effort to inform consumers about potential risks associated with certain products. This action aims to raise awareness and encourage appropriate actions by consumers to protect their health and safety. Informing the consignor: This action specifically relates to notifying the original sender about identified hazards or non-compliance. By informing the consignor, the responsible parties can take necessary actions, such as investigation, corrective measures, or improved quality control processes.

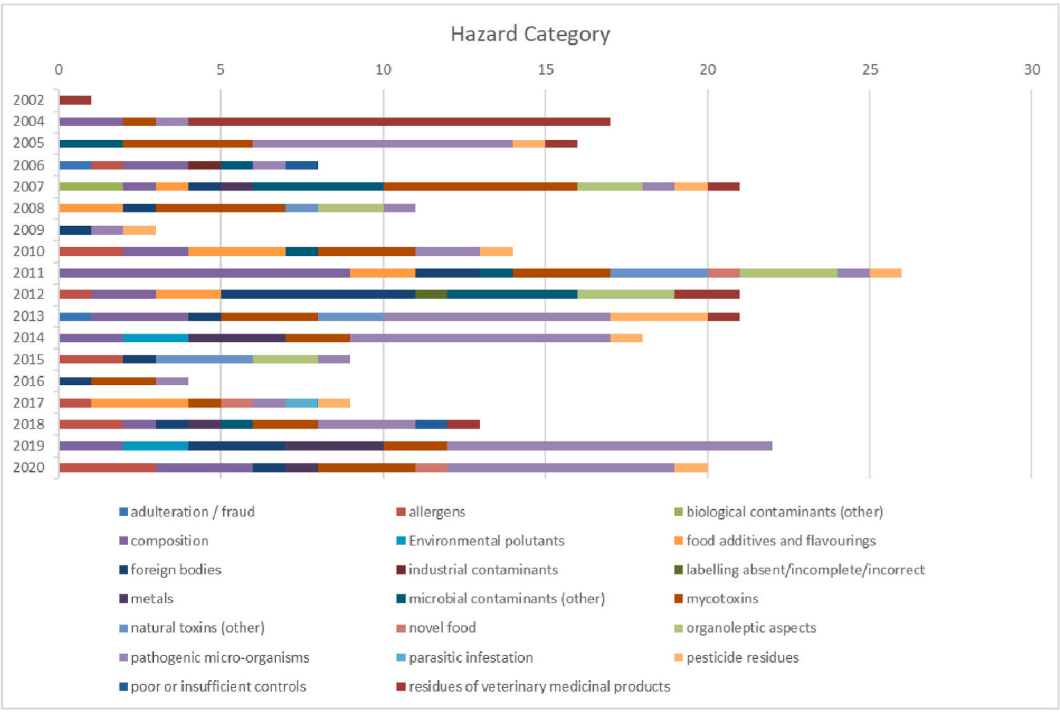

Fig. 4. Frequency Distribution of Hazard Categories Caption: Year-by-year distribution of hazard categories food from the country-of-origin Slovak Republic within the RASFF database, spanning the period from 2002 to 2022.

3.4. Hazard category

The data used in this analysis consists of the counts of different hazard categories recorded each year. The hazard categories include adulteration/fraud, allergens, biological contaminants, composition, environmental pollutants, food additives and flavorings, foreign bodies, industrial contaminants, labeling errors, metals, microbial contaminants, mycotoxins, natural toxins, novel food, organoleptic aspects, pathogenic micro-organisms, parasitic infestation, pesticide residues, poor or insufficient controls, and residues of veterinary medicinal products. Fig. 4 illustrates the frequencies of hazard categories from 2002 to 2020. Key observations include: The “adulteration/fraud” hazard category shows occurrences in 2006 and 2013. The “allergens” hazard category shows sporadic occurrences throughout the years, with an increase in 2010 and 2019. The “biological contaminants (other)” hazard category shows occurrences in 2007 and 2019. The “composition” hazard category shows variations over the years, with higher occurrences in 2011 and 2019. The “Environmental pollutants” hazard category shows occurrences in 2014 and 2018. The “food additives and flavorings” hazard category shows variations, with higher occurrences in 2008 and 2010. The “foreign bodies” hazard category shows variations, with higher occurrences in 2012 and 2019. The “industrial contaminants” hazard category shows an occurrence in 2006. The “labeling absent/incomplete/incorrect” hazard category shows an occurrence in 2011. The “metals” hazard category shows variations, with higher occurrences in 2014 and 2019. The “microbial contaminants (other)” hazard category shows variations, with higher occurrences in 2005, 2010, and 2018. The “mycotoxins” hazard category shows variations, with higher occurrences in 2005, 2006, and 2012. The “natural toxins (other)” hazard category shows variations, with higher occurrences in 2008 and 2015. The “novel food” hazard category shows occurrences in 2011 and 2020. The "organoleptic aspects" hazard category shows variations, with higher occurrences in 2008 and 2011. The “pathogenic micro-organisms” hazard category shows variations, with higher occurrences in 2004, 2011, and 2019. The “parasitic infestation” hazard category shows an occurrence in 2016. The “pesticide residues” hazard category shows variations, with higher occurrences in 2005, 2009, and 2014. The "poor or insufficient controls" hazard category occurred in 2006 and 2018. The “residues of veterinary medicinal products” hazard category shows variations, with higher occurrences in 2004 and 2011.

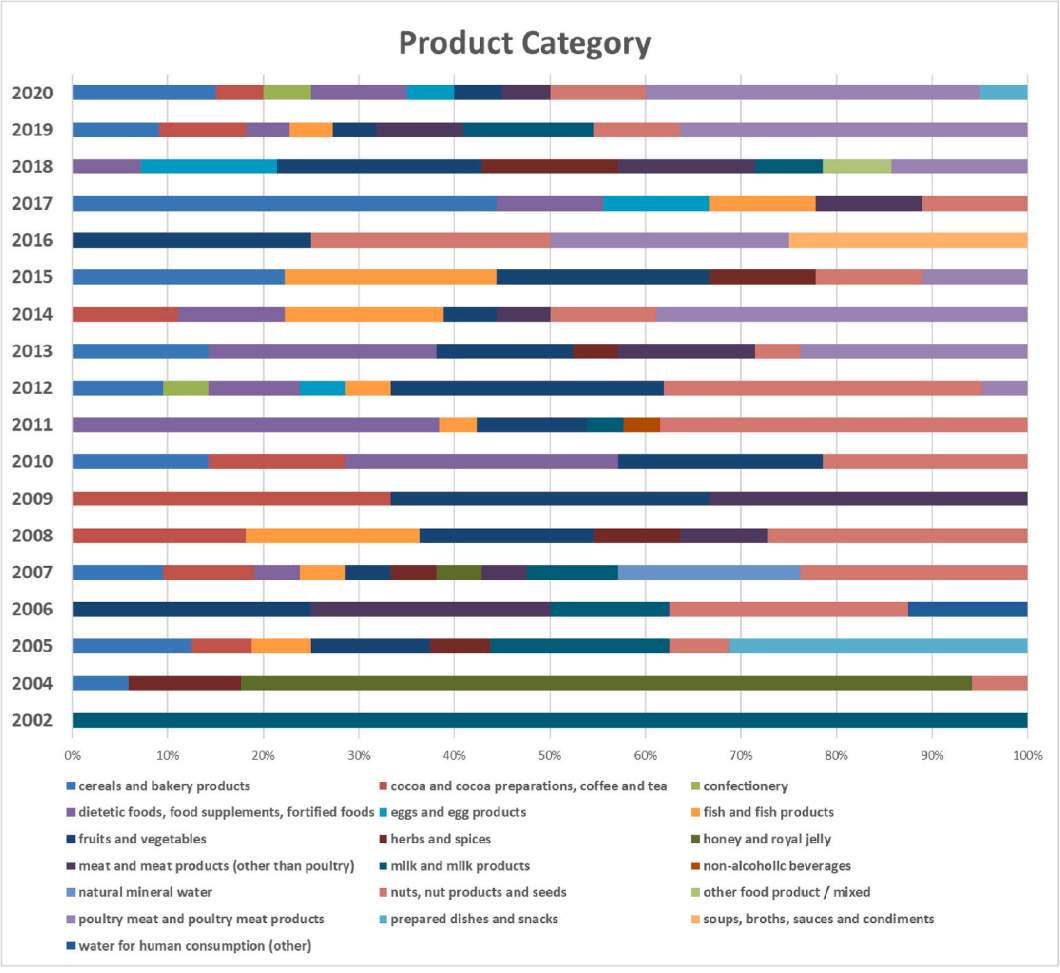

Fig. 5. Frequency Distribution Product Category Caption: Year-by-year distribution of hazard categories food from the country-of-origin Slovak Republic within the RASFF database, spanning the period from 2002 to 2022.

The data shows sporadic occurrences of different hazard categories throughout the years, indicating that food safety issues have been identified and addressed. Hazard categories such as "allergens" and "foreign bodies" have shown multiple occurrences, suggesting the importance of effective controls and prevention measures in these areas. Some hazard categories, like "adulteration/fraud" and "residues of veterinary medicinal products", have shown specific years with higher occurrences, highlighting the need for continued monitoring and enforcement to prevent such incidents. The presence of hazard categories such as "biological contaminants", "environmental pollutants", and "metals" highlights the importance of monitoring and controlling factors beyond intentional adulteration or contaminants. Categories like "mycotoxins" and "pesticide residues" demonstrate the significance of ongoing efforts to monitor and regulate the levels of these substances in food products. The occurrence of hazards related to labeling, organoleptic aspects, and poor controls suggests the need for enhanced quality control processes and stricter adherence to labeling regulations. Overall, the data underscores the importance of continuous monitoring, regulatory measures, and industry-wide awareness to ensure food safety and prevent hazards related to adulteration, contaminants, allergens, and other factors.

3.5. Product category

The data analyzed in Fig. 5 includes various product categories such as cereals and bakery products, cocoa and cocoa preparations, coffee and tea, confectionery, dietetic foods, food supplements, fortified foods, eggs and egg products, fish and fish products, fruits and vegetables, herbs and spices, honey and royal jelly, meat and meat products, milk and milk products, non-alcoholic beverages, natural mineral water, nuts, nut products and seeds, poultry meat and poultry meat products, prepared dishes and snacks, soups, broths, sauces and condiments, and water for human consumption. The analysis aims to identify significant trends and patterns in the occurrence of hazards within these product categories over time. However, here are some general observations based on the provided data: "Dietetic foods, food supplements, fortified foods" and "nuts, nut products and seeds" categories have the highest numbers in some years, with peak values of 10 in the years 2011 and 2012 respectively. "Honey and royal jelly" had an unusual spike in 2004 with a count of 13, but remained at 0 for the rest of the years. The "Poultry meat and poultry meat products" category has shown a significant increase over the years, particularly from 2012 to 2020. The "natural mineral water" category has an unusual spike in 2006 with a count of 4, but remained at 0 for all other years. Many categories such as "confectionery", "eggs and egg products", "non-alcoholic beverages", "other food product/mixed", "prepared dishes and snacks", "soups, broths, sauces and condiments", and "water for human consumption (other)" generally have low counts throughout the years. The analysis of the RASFF notification data presented several noteworthy findings. The annual distribution of notifications in the alerts category indicated fluctuations in the number of identified hazards or risks associated with specific products. Significant spikes in alerts were observed in 2007 and 2019, suggesting years with increased safety concerns. Conversely, 2009 had the lowest number of alerts, implying a year of lower identified hazards. In the information category, the number of notifications varied irregularly across the years, with peaks in 2011 and 2012 indicating periods of enhanced transparency and knowledge dissemination within the RASFF system. Studies on the RASFF system have often focused on evaluating its effectiveness in ensuring food safety and identifying areas for improvement. For example, some authors have investigated the responsiveness and efficiency of the RASFF system in addressing identified hazards [20]. These studies often emphasize the importance of timely notifications, effective communication, and coordinated actions among member countries to mitigate risks and protect consumers. Furthermore, research on food safety systems in different countries or regions may offer valuable insights for comparison [21]. For instance, studies have analyzed the effectiveness of food safety alert systems in the European Union, the United States, and other countries [22]. These comparative analyses can shed light on the strengths and weaknesses of different systems, highlighting best practices and potential areas for improvement. Additionally, studies on risk communication and consumer behavior in response to food safety incidents can provide valuable context for understanding the impact of RASFF notifications. Research has explored consumer perceptions, trust, and responses to food safety alerts or recalls [23]. Understanding consumer attitudes and behaviors can help improve risk communication strategies and enhance consumer trust in food safety systems. Food safety principles require reliable and impartial monitoring of established quality indicators [24].

3.6. Temporal analysis of aggregate occurrence of reports from the rapid alert monitoring system

Table 1 displays the temporal evolution of the cumulative occurrence of reports, which includes both alerts and pieces of information.

Statistical Test for Overall Seasonality: Variables: dq2, dq3, dq4, Sum of Coefficients: 1.96, Standard Error: 2.63, Test Statistic: $Z = 0.74$, p-value: 0.45, The test is not significant at $p > 0.05$.

Statistical Test for Ordinal Independence: Test for Autocorrelation (up to Order 4), Null Hypothesis: Absence of autocorrelation, Ljung-Box Test Statistic: 1.18, P-value: P(Chi-square(4) > 1.18) $= 0.88$, The test is not significant at $p > 0.05$.

Statistical Test for Constant Variance: Test for ARCH (up to Order 4), Null Hypothesis: No ARCH effect detected, Test Statistic: LM $= 2.72$, p-value: P(Chi-square(4) > 2.72) $= 0.60$, The test is not significant at $p > 0.05$.

Interpretation of Results.

a) There is no statistically significant trend detected in the temporal reporting pattern over the study duration.
b) A statistically significant seasonal component in the report count was not identified.
c) Report numbers show ordinal independence with a consistent variance, leading to the conclusion of a random occurrence pattern.
d) On average, the number of reports per quarter stands at three, with a typical variability range of 0–9 (accounting for 90 % of the data).

In Fig. 9, a graph displays the actual versus the modeled values, demonstrating that the report count does not exhibit a significant trend or seasonality. Fig. 10 presents a histogram detailing the distribution of the quarterly report numbers. The distribution of these numbers leans slightly rightward.

3.7. Statistical relationship analysis between product and risk categories

These selected dimensions result in three distinct diagrams, each representing two dimensions. These diagrams aid in understanding the relationships among categories. The diagrams illustrate several key insights: The positioning of the categories for the two variables relative to the coordinate axis' center. Categories further from the center showcase a distinct profile in terms of the secondary variable, warranting immediate interpretation. As we approach the center, categories exhibit declining specificity, gradually resembling the average composition. Categories forming an acute angle towards the midpoint of the axes, while maintaining a near-equidistant position from the center, indicate a strong association.

Fig. 6, representing dimensions 1 and 2, highlights: A notably elevated occurrence of the risk category "residues" in the "honey" product category when contrasted with other products.

An enhanced occurrence of risk categories "composition" and, to a milder degree, "pesticides" for the "dietetic" product. A pronounced incidence of the "pathogenic" risk category for "poultry", "snacks", and "meat", and to a slighter extent, the "metals" risk for "meat". A substantial occurrence of the "pollutants" risk for the "cocoa" product.

Fig. 7, showcasing dimensions 1 and 3, supplements the previous relationships by emphasizing the shared occurrence of several risks. Particularly, the "toxins" and "organoleptic" risks stand out prominently for "cereals" and "fruits".

Fig. 8, which illustrates dimensions 2 and 3, adds to the above relationships by highlighting a significant prevalence of "microbial" and "allergens" risks in "natural" and "cereals" products.

Drawing from the relative positions of the markers across diagrams, several conclusions are discernible: Product categories "poultry", "snacks", and "meat" exhibit analogous risk profiles concerning risk incidence. "Honey" and "dietetic" products manifest distinct profiles, setting them apart from other categories. The residual products display minor differentiation regarding risks, with their risk profiles being more uniformly dispersed.

4. Conclusion

In conclusion, the analysis of the RASFF data provides valuable insights into the trends and patterns of notifications, actions taken,

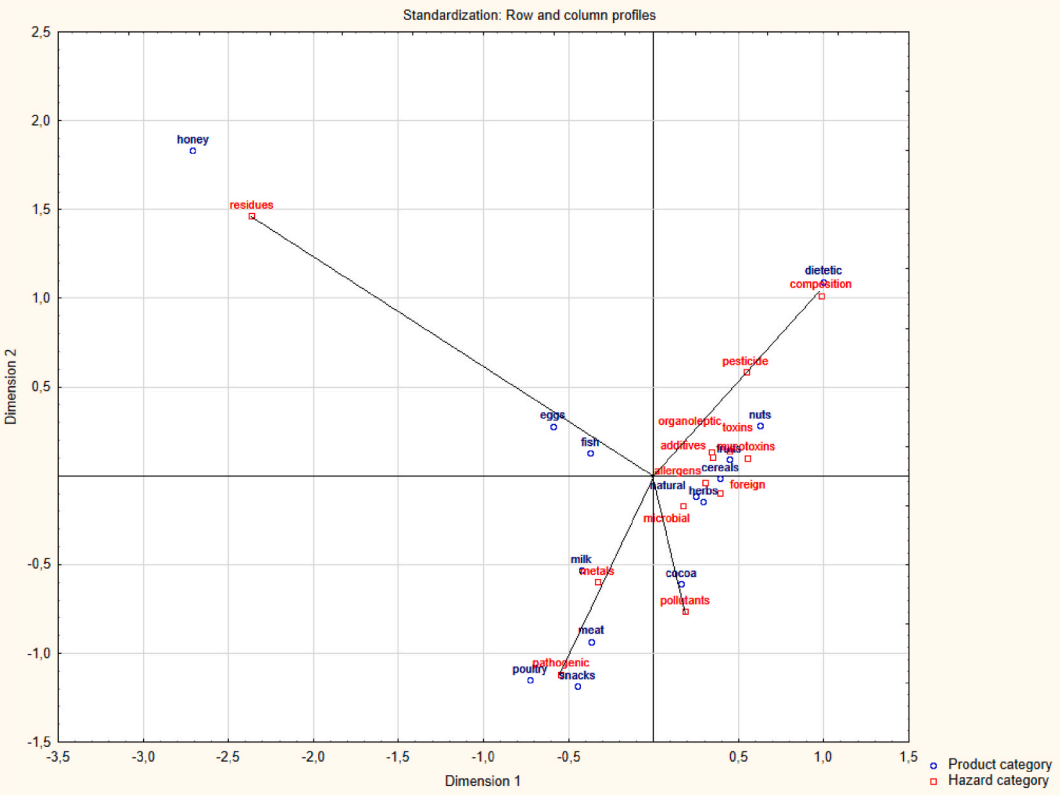

Fig. 6. Diagram of dimensions 1 and 2.

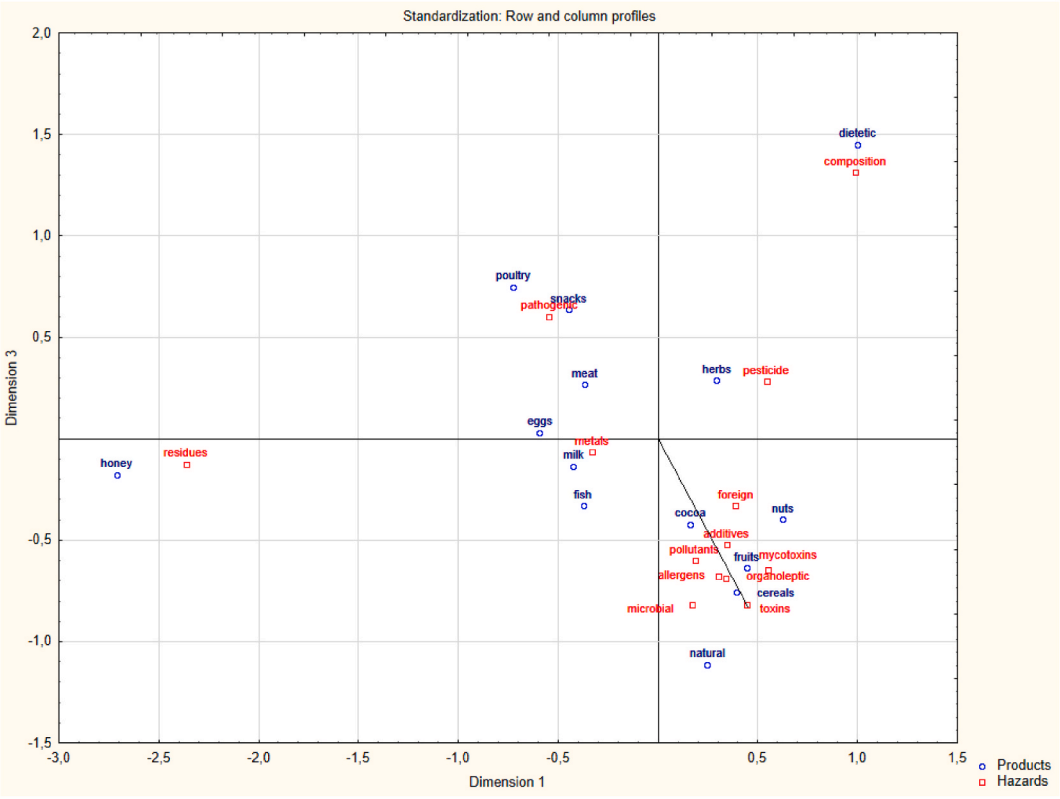

Fig. 7. Diagram of dimensions 1 and 3.

hazard categories, and product categories in the food industry. The findings highlight the dynamic nature of food safety issues and the importance of continuous monitoring and regulatory measures to ensure consumer protection. The fluctuating numbers of alerts and information notifications indicate the presence of identified hazards and the increased transparency within the RASFF system over time. This suggests an improved ability to detect and communicate risks, ultimately contributing to enhanced food safety practices. A range of actions is taken in response to identified hazards, with destruction and product recall or withdrawal being the most frequently employed measures. These actions demonstrate a proactive approach in eliminating unsafe or non-compliant products from the market and protecting consumer health. The analysis of hazard categories reveals sporadic occurrences, emphasizing the need for ongoing monitoring and targeted interventions. Certain categories, such as dietetic foods, food supplements, and fortified foods, exhibit higher occurrences of hazards in specific years, highlighting the importance of implementing stringent safety measures and quality control processes within these product categories. It is worth noting that the evaluation is based solely on the provided data, and the effectiveness of the actions taken and the context surrounding the observed trends require further investigation. Additionally, the results underscore the significance of industry-wide collaboration, regulatory enforcement, and consumer awareness in maintaining food safety standards. Overall, the findings from this analysis contribute to a better understanding of the dynamics of hazards in the food industry and emphasize the need for ongoing vigilance, regulatory measures, and continuous improvement efforts to ensure the safety and compliance of food products.

5. Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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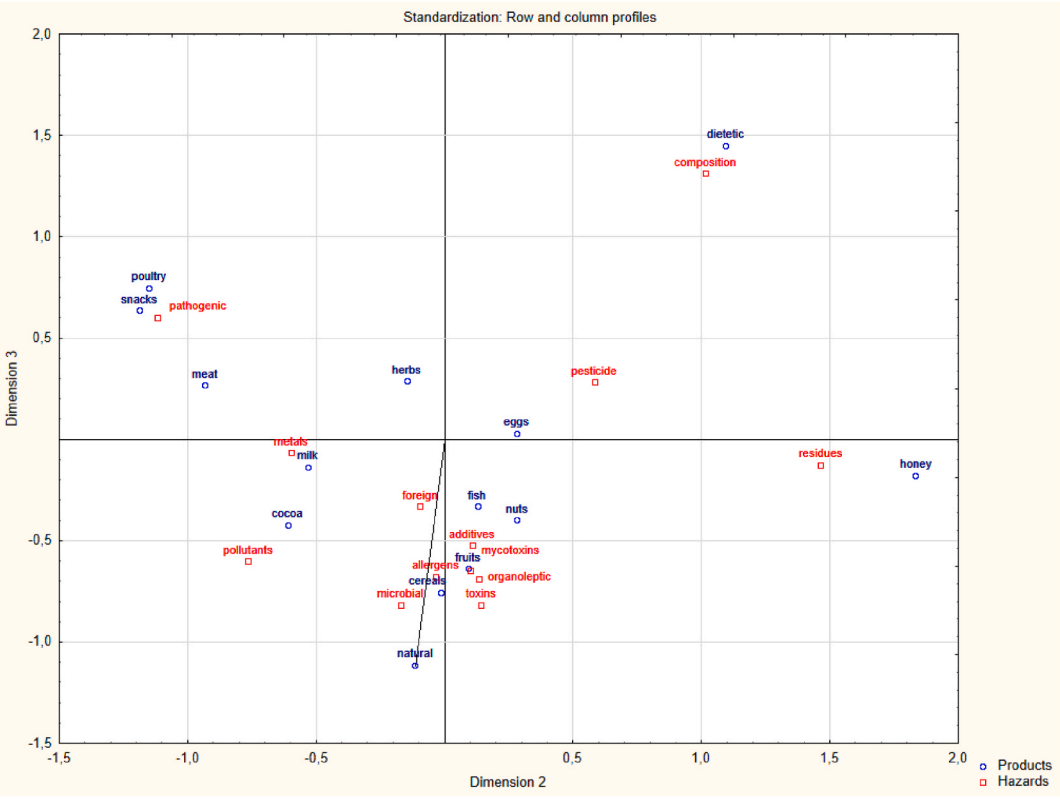

Fig. 8. Diagram of dimensions 2 and 3.

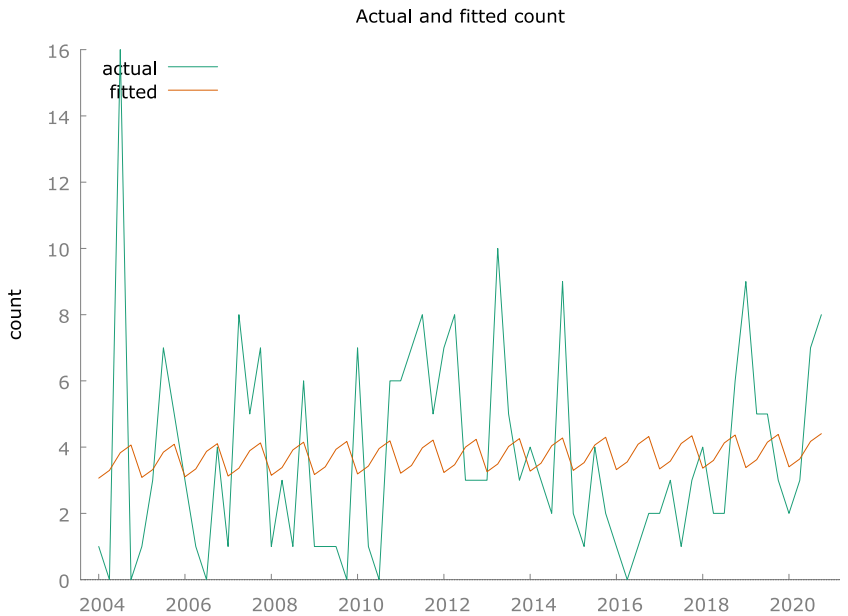

Fig. 9. Graph of actual and modeled values.

Data availability statement

The processed data used in this research are present at:
https://drive.google.com/drive/folders/16m5eFbeO0tDMNSmJwpyB-4ozdeZbjSqv?usp=sharing.

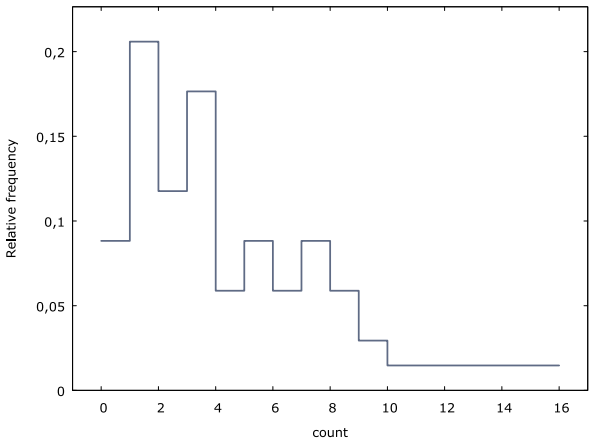

Fig. 10. A histogram of the distribution of the number of quarterly reports.

CRediT authorship contribution statement

Jozef Čapla: Writing - original draft, Conceptualization, Funding acquisition, Investigation, Methodology, Validation, Writing - review & editing. **Peter Zajác:** Conceptualization, Funding acquisition, Investigation, Methodology, Writing - original draft, Writing - review & editing. **Jozef Čurlej:** Methodology, Investigation, Writing - review & editing. **Lucia Benešová:** Investigation, Methodology, Writing - review & editing. **Silvia Jakabová:** Writing - review & editing, Investigation, Methodology. **Martina Fikselová:** Writing - review & editing. **Alica Bobková:** Writing - review & editing.

Declaration of competing interest

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

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None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e23146.

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