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Dipartimento Territorio e Sistemi Agro-forestali
Department of Land, Environment Agriculture and Forestry

Corso di laurea magistrale/Second Cycle Degree (MSc) in Food and Health

Food Fraud in the EU: Analysis of Reports in the Rapid Alert System for Food and Feed

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Declaration

     I hereby declare that this dissertation is a result of my own research work, it contains no material previously published by another person or material which has been accepted for the award of any other degree in the University or elsewhere, except where due acknowledgement has been made in the text.

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ABSTRACT

Food fraud is a major concern to public health, consumer confidence, and the integrity of the EU food industry. Although the EU legal framework lacks a clear definition for food fraud, it provides regulations like the General Food Law, Food Information to Consumers Regulation, and Official Controls Regulation, which serve as a foundation also for addressing fraudulent practices. The General Food Law was passed in 2002, but the specific criteria for identifying food fraud were not defined until 2019. Nevertheless, incidents such as the dioxin crisis in Belgium in 1999, the illegal dyes crisis in 2005, the melamine crisis in 2008, the Chinese milk scandal in 2008, and the Horsemeat scandal in 2013 highlight the financial and public health consequences of food fraud. In this study, food fraud and adulterations reported in the RASFF database from 2005 to 2021 (n=2031) were analysed to identify the overall pattern and trend. The United Kingdom emerged as a focal point with 31.8% of all food fraud notifications, followed by Italy (9.0%). China and India were identified as the predominant origins of food fraud, constituting 16.94% and 11.96% of the reported cases, respectively. The study found that nuts, nut products, and seeds accounted for the highest proportion of fraud/adulteration cases at 22.01%. Followed by fruits and vegetables (10.49%), and meat and meat products other than poultry (10.44%). Furthermore, the study identified health certificates as the common manipulated aspect in food fraud, representing 40.92% of reported cases. In addition, mislabelling, adulteration, and tampering were common with meat and meat products, whereas document forgery was more frequent with nuts and seeds. Grey market activities were prevalent among dietetic foods, while counterfeiting was primarily observed in soups and sauces. From the findings, it is recommended that the regulatory authorities within the EU collaborate and work together to identify each country's unique challenges and develop specific prevention strategies accordingly. Further, the collaborative efforts should focus on sharing intelligence, harmonising standards, and developing joint initiatives to combat cross-border food fraud incidents. This initiative should consider and incorporate WTO rules to ensure fair and transparent trade while safeguarding consumers. The EU should also consider developing specialised regulations and standards for each high-risk food category. Targeted campaigns and awareness programs should be launched to help consumers identify vulnerable products and understand labelling regulations.

RIASSUNTO

La frode alimentare rappresenta una grave preoccupazione per la salute pubblica, la fiducia dei consumatori e l'integrità dell'industria alimentare dell'UE. Sebbene il quadro giuridico dell'UE non fornisca una definizione chiara della frode alimentare, esso prevede regolamenti come il Regolamento generale sull'alimentazione, il Regolamento sull'informazione alimentare ai consumatori e il Regolamento sugli ufficiali di controllo, che fungono anche da base per affrontare le pratiche fraudolente. Il Regolamento generale sull'alimentazione è stato approvato nel 2002, ma i criteri specifici per identificare la frode alimentare non sono stati definiti fino al 2019. Tuttavia, incidenti come la crisi della diossina in Belgio nel 1999, la crisi dei coloranti illegali nel 2005, la crisi della melamina nel 2008, lo scandalo del latte cinese nel 2008 e lo scandalo della carne di cavallo nel 2013 mettono in evidenza le conseguenze finanziarie e per la salute pubblica della frode alimentare. In questo studio, sono stati analizzati la frode alimentare e le adulterazioni segnalate nel database RASFF dal 2005 al 2021 (n = 2031) al fine di identificare il modello generale e la tendenza. Il Regno Unito è emerso come un punto focale con il 31,8% di tutte le notifiche di frode alimentare, seguito dall'Italia (9,0%). Cina e India sono stati identificati come le principali origini della frode alimentare, costituendo rispettivamente il 16,94% e l'11,96% dei casi segnalati. Lo studio ha scoperto che noci, prodotti a base di noci e semi rappresentavano la più alta percentuale di casi di frode/adulterazione con il 22,01%. Seguiti da frutta e verdura (10,49%) e carne e prodotti a base di carne diversi dalla carne di pollame (10,44%). Inoltre, lo studio ha identificato i certificati sanitari come l'aspetto più comunemente manipolato nella frode alimentare, rappresentando il 40,92% dei casi segnalati. Inoltre, l'etichettatura erronea, l'adulterazione e la manomissione erano comuni con la carne e i prodotti a base di carne, mentre la falsificazione di documenti era più frequente con noci e semi. Le attività del mercato grigio erano diffuse tra gli alimenti dietetici, mentre la contraffazione era osservata principalmente nelle zuppe e nelle salse. Dai risultati, si raccomanda che le autorità regolatorie dell'UE collaborino e lavorino insieme per identificare le sfide uniche di ciascun paese e sviluppare strategie di prevenzione specifiche di conseguenza. Inoltre, gli sforzi collaborativi dovrebbero concentrarsi sulla condivisione di informazioni, sull'armonizzazione degli standard e sullo sviluppo di iniziative comuni per combattere gli incidenti di frode alimentare transfrontaliera. Questa iniziativa dovrebbe prendere in considerazione e incorporare le regole dell'OMC per garantire un commercio equo e trasparente mentre tutela i consumatori. L'UE dovrebbe anche considerare lo sviluppo di regolamenti e standard specializzati per ciascuna categoria di alimenti ad alto rischio. Dovrebbero essere lanciate campagne mirate e programmi di sensibilizzazione per aiutare i consumatori a identificare i prodotti vulnerabili e comprendere le normative sull'etichettatura.

CHAPTER 1

INTRODUCTION

Food fraud raise significant concerns in the food industry, posing severe risks to the public, businesses, and economies. The complex and globalised nature of the contemporary food supply chain has amplified the possibilities of fraudulent activities, thereby presenting significant challenges to regulators and industry stakeholders (Spink et al., 2019). Despite the European Union's (EU) absence of a legal definition for food fraud, the Union recognises the importance of food fraud as a critical issue within the food industry. This is because these issues require attention in order to retain consumers' trust in the food they consume and to protect the public.

Consequently, the EU has enacted several legal provisions, which are legislative measures to improve food authenticity and prevent food fraud (Ulberth, 2020). These legal provisions consist of regulations aimed at reducing fraudulent practices, enhancing food authenticity and safety, hazard analysis and critical control points (HACCP), good manufacturing practices (GMP), protocols for official controls, and verification of compliance across the entire food supply chain (Previti et al., 2022). Some of the regulations which set provisions on food fraud have been revised and even repealed to address emerging risks and challenges in the food sector. Despite these efforts, food fraud persists, highlighting new requirements for ongoing vigilance and innovation in food fraud prevention. It is, therefore, critical to provide a comprehensive overview of food fraud due to the ever-changing food supply chain.

This comprehensive overview of food fraud can have significant implications in multiple areas. First, it can help with risk assessment and prioritisation by identifying high-risk foods and fraudulent practices. This data assists regulators in successfully allocating resources and implementing targeted plans. Second, the findings can support the necessity for tougher sanctions and deterrence methods against food fraud, emphasizing the importance of stricter penalties to discourage fraudulent activities. Finally, the analysis can contribute to evidence-based policymaking by providing empirical evidence and insights that may be used to develop strategies and standards to address food fraud risks and maintain the food supply's integrity.

It is important to note that each Member State has its own legal definition of food fraud, which does not necessarily overlap with the EU's definition of "fraud notification" as

stated in Commission Implementing Regulation (EU) 2019/1715[1]. As a result, developing a thesis and investigating the different definitions of food fraud among Member States is beyond the scope of the EU and the Food and Health course. As a result, the focus of this thesis will be on the EU's meaning of "food fraud", inferred from the definition of "fraud notification" outlined in Commission Implementing Regulation (EU) 2019/1715, as well as the operational criteria referred to when determining whether a case should be considered a non-compliance or suspicion of fraud (EC, Directorate General for Health and Food Safety, 2020).

It is also worth noting that the operative criteria to establish a case as food fraud were only established in 2019. Despite this, several RASFF reports, for instance, mention fraud. The RASFF annual report of 2009, for example, considered fraud as important food incidents, such as the 1999 dioxin crisis in Belgium, the 2005 illegal dyes crisis, and the 2008 melamine crisis, which had a common root cause of intentional fraud for financial gain (EC, Directorate-General for Health and Consumers, 2010). Furthermore, the RASFF annual report of 2015 considered fraud as alleged violations related to non-compliance with labelling, suspicion of illegal exports, and prohibited or processes treatments applied to particular foodstuffs (EC, Directorate General for Health and Food Safety, 2016). Although no official definition of food fraud existed then, references to fraud are in these RASFF reports, allowing some considerations to be drawn.

This study considers all food fraud cases from the RASFF reports, which includes notifications not only from EU Member States but also from countries (Norway, Iceland, and Switzerland) that take part in the RASFF and report in the system. Thus, the conclusions drawn from the analysis can instead be referred just to the EU, as the EU is considered a leading entity (an example) also for non-EU countries. In addition, the conclusions are predominantly relevant to the EU's context, given its integral role as a pioneer in establishing and sharing intelligence on food safety, authenticity, and integrity frameworks with these countries. Insights into single countries would require further in-depth analysis, which could be the subject of further research.

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[1] Commission Implementing Regulation (EU) 2019/1715 of 30 September 2019 laying down rules for the functioning of the information management system for official controls and its system components (the IMSOC Regulation), *OJ L 261, 14.10.2019, p. 37-96.*

1.1 The History of Food Law and Regulations

The integrity of food systems has been ensured by governments for generations through the enactment of food laws, particularly food regulations. Even though it is clear that the primary focus of food laws shifts over time, the fundamental reason to safeguard against fraud in the food business, which expanded to the prevention of the sale of unsafe food (Burditt, 1995), has remained the same. Food laws and regulations have guided policymakers to adopt systems and strategies for facilitating trade and rapidly preventing the sale of food that is contaminated or altered in any way to deceive consumers (Food and Agriculture Organization of the United Nations & World Health Organization, 2003).

In ancient Egyptian and Mosaic laws, provisions were established to prevent meat contamination. In India, adulterating edible fats and grains has been against the law since more than 2000 years ago. And according to available documents, under Roman civil law, Rome provided regulations and state control over food supplies and safeguarded consumers against poor quality and fraud (Lasztity et al., 2004).

Early advocates of food regulation included a number of the following individuals: Theophrastus (370–285 B.C.), who wrote about the use of artificial flavours in food; Cato (234–149 B.C.), who proposed a method for determining if wine has been adulterated with water; Pliny the Elder (23–79 A.D.), who described the adulteration of bread with chalk, vegetable meals, and cattle feed; and Galen (131–201 A.D.), who cautioned against adulterating products like pepper (Burditt, 1995).

The Assize of Bread and Ale, first implemented in 1266 under Henry III's reign, was the earliest food regulation in England. This 13th-century law contained detailed regulations surrounding bread and beer quality, weight, and cost. For instance, the price of beer had to be determined by the cost of the raw materials used to produce the beer (MacMaoláin, 2015).

Beginning in the early 1880s, State legislatures in the United States started enacting pure food and pure dairy laws. By 1900, nearly all States had enacted some legislation on pure food or dairy, making it illegal to market adulterated food products (Law, 2003).

In 1962, the EU adopted its first food directive, Directive 62/2645/EEC[2], which addressed using colours in foods (Dikshit & Tallapragada, 2018). And in 2002, the European

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[2] Council Directive 62/2645/EEC of 23 October 1962 on the approximation of the rules of the Member States concerning the colouring matters authorized for use in foodstuffs intended for human consumption, *OJ 115, 11.11.1962, p. 2645–2654.*

Parliament and Council established Regulation (EC) No 178/2002[3] to serve as the General Food Law.

1.2 The European Union Legal Provisions on Food Fraud

Without prejudice with what we will say shortly, the current state of the EU legal framework reveals a notable absence of an explicit definition for food fraud. This absence is not limited to the EU alone, as major trading partners of the EU also lack a defined framework for addressing food fraud. However, it is important to note that EU food law incorporates provisions relevant to addressing and combating food fraud (Ulberth, 2020). These provisions serve as an important foundation for addressing issues related to fraudulent practices in the food industry and ensuring the safety and integrity of the food supply chain:

- Regulation (EC) No 178/2002 (The General Food Law) refers in Article 8 (Protection of consumers' interests) that food law shall aim at the protection of consumers' interests and should provide a basis to enable informed food choices. The Article 8 specifically addresses the prevention of fraudulent or deceptive practices, the adulteration of food, and any other misleading practices that may misguide consumers. EU Regulation (EC) No 178/2002 is a crucial piece of legislation that sets the main food law principles and criteria within the European Union. It establishes the basis for maintaining high protection for consumers' health and food interests.

- Regulation (EU) No 1169/2011[4] (The Food Information to Consumers Regulation) refers in Article 7 (Fair information practices) point 1 that food information should not be misleading, particularly regarding the characteristics of the food. These characteristics include its nature, identity, properties, composition, quantity, durability, country of origin or place of provenance and method of manufacture or production. It prohibits suggesting that foods possess special characteristics when

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[3] Regulation (EC) No 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, *OJ L 31, 1.2.2002, p. 1-24*.

[4] Regulation (EU) No 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, *OJ L 304, 22.11.2011, p. 18–63.*

other similar foods possess the same features and attributing false effects or properties to food. It also discourages emphasizing the presence or absence of specific ingredients and nutrients through appearance, descriptions, or pictorial representations when such components have been substituted with different ones.

- Regulation (EU) 2017/625[5] (The Official Controls Regulation) refers in Article 9 (General rules on official controls) points 1 and 2 that, in brief: (i) Competent authorities shall perform official controls on operators regularly, based on risk, and with appropriate frequencies. Factors such as identified risks, indications of consumer deception, operators' records of official controls and compliance history, reliability and results of internal and third-party controls, and any information suggesting non-compliance with rules are considered (ii) Official controls shall be specifically aimed at identifying intentional violations of food-related rules, including fraudulent or deceptive practices. Information on such violations is shared through administrative assistance mechanisms, enhancing the ability to detect and address potential violations.

1.3 Overview of the EU's Food Authenticity and Safety Control and Inspection System

It is imperative to note that the title "Food Authenticity and Safety Control and Inspection System" does not refer to a single, unified system, but rather, the title is employed to metaphorically signify the integration of the diverse measures in place for controlling and inspecting food authenticity and safety.

The EU has one of the world's most comprehensive food authenticity and safety control and inspection systems, as mandated by the General Food Law Regulation (Regulation (EC) No 178/2002). The system is founded on an extensive regulatory framework laying out food authenticity and safety standards, core principles, practices, and regulations regarding food adulteration, additives, contaminants, traceability, and labelling. It is designed to prevent consumer deceit, protect consumers' health, and prevent the spread of foodborne diseases

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[5] Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (Official Controls Regulation), *OJ L 95, 7.4.2017, p. 1–142.*

by ensuring that food products are safe for human consumption and meet strict quality standards (Regulation (EC) No 178/2002 referred in Article 5, 8, 14, 16, 17, 18 and 19).

The EU's food safety control and inspection system uses a risk-based approach and follows the "from farm to fork" principle (Regulation (EC) No 178/2002 referred in Article 4, 5, 6, 14, 17, 18 and 19; Pettoello-Mantovani & Olivieri, 2022; Reilly, 2007). This implies that food safety measures are prioritised by the level of risk they pose to the general public's health. Further, every phase of the food supply chain, from initial production to processing, distribution, and consumption, is guided by legislation and is subject to inspection. With this strategy, national authorities can target the areas with the highest risk and allocate their resources more effectively for control and intervention (Boqvist et al., 2018). In addition, the system includes checks, inspections, audits, and sampling to ensure compliance with food regulations. The EU Member States' competent authorities carry out these activities, while the European Commission (EC) oversees and coordinates them (McEvoy, 2016).

The European Food Safety Authority (EFSA) plays a vital role in the system by providing independent scientific advice on food safety and authenticity issues to EU institutions and Member States. EFSA collaborates closely with the European Commission and the Member States' competent authorities to ensure that EU food safety regulations are followed (Martirosyan & Singharaj, 2016). The EFSA is responsible for assessing food safety. In turn, the European Commission develops and implements policies based on EFSA reports, which are enforced by national authorities in each Member State. These authorities are responsible for conducting inspections and enforcing EU food regulations within their respective countries to meet the EU's food standards.

The EFSA conducts risk assessments to provide independent scientific advice on food safety and authenticity issues by using the best available scientific evidence while also considering the benefits and risks of other food products. The European Commission and Member States use EFSA's risk assessments to guide their risk management choices. It entails characterising and identifying hazards, assessing exposure, and identifying risks.

Risk communication (Regulation (EC) No 178/2002 referred in Article 3, 22 and 40) is a part of the EU's control and inspection system for food safety and authenticity. It is the duty of the European Commission, EFSA, and Member States to inform the public about food safety issues, including communications on potential risks and strategies for reducing those risks through a variety of channels, for example, public consultations and media outreach.

1.4 Overview of Hazard Analysis and Critical Control Points and Good Manufacturing Practices

Food industries use the concepts of Hazard Analysis and Critical Control Points (HACCP) (Regulation (EC) No 852/2004[6] particularly referred in Article 5) and Good Manufacturing Practices (GMPs) to ensure the safety, authenticity, and quality of their products. Both practices share a common objective of ensuring the production of safe and harmless products for consumers. They employ systematic and scientific evaluations to assess manufacturing processes thoroughly. Their goal is to implement robust protocols and standards prioritizing consumer health and well-being.

GMPs are requirements that guarantee that food products are consistently manufactured and monitored according to quality and safety standards (Jarvis, 2014; Liboreiro, 2013). In contrast, HACCP is a systematic approach for identifying, evaluating, and controlling potential hazards in food manufacturing processes (Hulebak & Schlosser, 2002; Wernaart & van der Meulen, 2022). By utilising GMPs and HACCP, food industries play a vital role in maintaining the integrity and trustworthiness of the food industry.

1.4.1 Good Manufacturing Practices (GMPs)

GMPs play a crucial role in ensuring the authenticity, safety, and high quality of food products by providing a standardised framework for manufacturing processes, which is crucial for regulatory compliance. GMPs are required by regulatory organisations like the Food and Drug Administration (FDA) and the World Health Organization (WHO) to guarantee that food products are manufactured in a controlled environment to comply with specific quality and safety standards.

These guidelines cover various aspects of production, including personnel, facilities, equipment, documentation, and hygiene. They outline the proper manufacturing procedures and techniques from the raw materials to the finished products (CDER, 2021; CFSAN, 2021). Keeping the manufacturing process consistent, under control, and documented is the main objective of GMPs. The utilisation of GMPs serves to mitigate potential contamination, spoilage, and hazardous incidents that may arise in the production process (CDER, 2021; CFSAN, 2021). Furthermore, GMPs aid in lessening the possibility of cross-contamination

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[6] Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs, *OJ L 139, 30.4.2004, p. 1–54*.

while ensuring the proper handling of apparatus, cleaning, and sanitation protocols (CDER, 2021). Additionally, GMPs guarantee that products meet the required benchmarks of quality and purity (CFSAN, 2021).

As WHO outlined, GMPs are a crucial aspect of quality assurance throughout the manufacturing process (WHO, 2014). They are vital in the EU's battle against food fraud as these practices ensure food integrity by guiding production, processing, and distribution processes. By adhering to GMPs, food businesses, particularly those in countries that export into the EU, can establish robust quality control, deterring fraud. These practices align with the EU's aims for consumer safety, fair trade, and authentic products, and their incorporation further highlights a food business' commitment to ensuring food safety and trustworthiness.

1.4.2 Hazard Analysis and Critical Control Points (HACCP)

HACCP is crucial in reducing food contamination during production, and it is applied at any phase of the food supply chain to final consumption. Implementing HACCP involves identifying critical control points within the production process and instituting measures to proactively manage hazards. Studies by Hulebak and Schlosser (2002) and Minor and Parrett (2017) confirmed the efficacy of implementing HACCP systems in reducing the occurrence of foodborne illnesses.

The implementation of HACCP is a crucial factor in meeting food safety regulations. Many countries require food manufacturers to adhere to HACCP protocols, as compliance with these regulations is crucial in guaranteeing that food is safe to consume and in preventing foodborne diseases. By following HACCP guidelines, companies can demonstrate their commitment to food safety and protect their customers from various health risks. HACCP incorporates comprehensive food production considerations such as hazard analysis, determining critical control points and limits, monitoring, corrective actions, and documentation, which are instrumental in preventing outbreaks (CFSAN, 2023).

The EU's approach to HACCP is established in Regulation (EC) No 852/2004. This regulation mandates food businesses to implement HACCP principles to ensure food safety. This requirement is reinforced and complemented by other regulations depending on the type of food product and the specific food sector. For instance, Regulation (EC) No 2073/2005[7] on

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[7] Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs, *OJ L 338, 22.12.2005, p. 1–26.*

microbiological criteria for foodstuffs in Article 3 emphasizes that food business operators shall take measures as part of their procedures based on HACCP principles, together with good hygiene practices to comply with the relevant microbiological criteria set out in Annex I of the regulation.

1.5 The European Union Food Fraud Network

The European Union Food Fraud Network (EU FFN) is part of a single entity: the Alert and Cooperation Network (ACN). The ACN is the network that makes it easier for Member States to collaborate on official controls in the agri-food chain and exchange administrative information. According to Commission Implementing Regulation 2019/1715 (Article 2), which established the ACN, the network is made up of the EU Agri-Food Fraud Network (EU FFN), the Administrative Assistance and Cooperation Network (AAC), and the Rapid Alert System for Food and Feed (RASFF). The three distinct networks are each responsible and in charge of separate aspects of the agri-food chain. The RASFF deals with non-compliances that have potential health risks (Commission Implementing Regulation 2019/1715 referred in Article 17, 18 and 20; EC, Directorate General for Health and Food Safety, 2022). The AAC handles non-compliances that do not pose health risks (EC, Directorate General for Health and Food Safety, 2022). Lastly, the EU FFN focuses on addressing suspicions of fraud within the agri-food chain (Commission Implementing Regulation 2019/1715 referred in Article 21; EC, Directorate General for Health and Food Safety, 2022).

The EU FFN's main objective is to tackle fraud in the marketing of food products that impact multiple EU Member States (Corini, 2019). The EU FFN, founded in 2013, is made up of competent authorities appointed by each EU Member State. Europol is also an affiliate of the network. The network is overseen and maintained by the European Commission's Directorate-General for Health and Food Safety (EC, Directorate General for Health and Food Safety, 2022). EU FFN connects the European Commission with liaison bodies appointed by Member States. These liaison bodies are tasked with offering administrative support to facilitate the exchange of information regarding possible cross-border violations of EU agri-food chain legislation (EC, Directorate General for Health and Food Safety, 2020). The network operates with the EC Knowledge Centre for Food Fraud and Quality (KC-FFQ) within the Joint Research Centre (JRC), as well as the European Anti-Fraud Office (OLAF) and the European

Union Agency for Law Enforcement Cooperation (Europol) (EC, Directorate General for Health and Food Safety, 2020).

The KC-FFQ is a source of current scientific information concerning food fraud and quality matters. It facilitates the exchange and dissemination of this knowledge and oversees market surveillance activities while operating an early warning and information system for food fraud (KC-FFQ, 2019). Additionally, the KC-FFQ offers expertise in food science, including researching the authenticity and quality of food provided within the EU (González-Vaqué & Vidreras, 2019). OLAF and Europol are responsible for conducting essential fraud investigations, and specifically, Europol also targets fake and inferior food and beverages (EC, Directorate General for Health and Food Safety, 2020). Collaboration among experts in the EU agri-food chain, law enforcement officers, customs officials, and judicial administrations is crucial for combating fraud in the agri-food industry, both at national and EU levels. The EU FFN facilitates and coordinates communication between competent authorities appointed by each Member State (Corini, 2019). The appointed contact and cooperation bodies are obligated to exchange essential information with their peers. This obligation enables the verification of compliance with agri-food chain regulations within the EU (EC, Directorate General for Health and Food Safety, 2021).

1.6 Food Fraud

1.6.1 Food Fraud under EU Legislation

Regulation (EC) No 178/2002 of the European Parliament and of the Council, generally known as 'The General Food Law,' is the legislation that establishes the European Food Safety Authority and the general principles and requirements of food law. It arose from the need for a uniform and consistent strategy to regulate the safety of the food supply chain in the EU. The Regulation aims to establish food policies that can guarantee a high degree of human health protection and the free circulation of commodities, contributing to the welfare of the EU and its social and economic interests. Also, the Regulation prevents misleading practices in the food supply chain. It broadens the scope of other policies on labelling and advertising in foods and food products placed on the market, taking into account the consumer's interests (Jurica et al., 2021).

The General Food Law, a comprehensive regulatory framework for food, is closely related to food fraud prevention and management. By establishing the regulation to ensure

food safety, quality and transparency, the General Food Law directly addresses food fraud by enforcing traceability, risk assessment, verification and enforcement mechanisms. Thus, the General Food Law helps prevent deceptive practices like adulteration, mislabelling and counterfeiting if food businesses follow the rules accordingly.

The term "fraud" in the agri-food chain is not defined under EU legislation. However, the definition of a "fraud notification" in iRASFF is provided by Commission Implementing Regulation (EU) 2019/1715, which highlights the key elements that must be taken into account. In this context, agri-food fraud refers to non-compliance concerning any suspected intentional action by businesses or people to deceive buyers and get an unfair advantage in breach of the rules referred to in Article 1(2) of Regulation (EU) 2017/625. This description applies beyond food fraud and covers other product categories, including plant health, animal health, and feed, since Article 1(2) broadens the scope of official controls to include the whole agri-food chain.

To determine whether a case should be classified as a "non-compliance" or "suspicion of fraud," four main operative criteria are referred to: (i) violations of EU rules, (ii) deception of customers, (iii) undue advantage, and (iv) intention (EC, Directorate General for Health and Food Safety, 2020). Firstly, one or more EU agri-food chain legislation rules must be violated. Secondly, there must be some consumer/customer deceit (for example, altered colouring, which hides the authentic quality and nature of a food or feed product). Since some of the product's properties are concealed, the deceptive element may pose a public health concern (such as undeclared allergens). Thirdly, the act must result in a direct or indirect financial advantage for the perpetrator. Finally, there must be the intent to replace a high-quality ingredient with a lower-quality one instead of accidental contamination during manufacturing. This intent is confirmed when various facts prove that some non-compliances, such as intentional replacement, are not accidental. These criteria are similar to those in place in member states of the EU for reporting fraud.

In response to the horsemeat scandal in 2013[8], the European Food Fraud Network (EU FFN) was established, and it assists EU member states in operating in line with Regulation (EU) 2017/625, which addresses official controls (Jurica et al., 2021). The Directorate General for Health and Food Safety handles communication on incidents of food fraud.

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[8] For further information on the horsemeat scandal in 2013 please refer to paragraph 1.8, page 14.

1.6.2 Definitions of Food Fraud from Academic Literature

Numerous definitions of food fraud have been proposed in academic literature. However, it is crucial to highlight that the actual definition of food fraud depends on legal provisions, making these academic definitions speculative because the conceptualization of food fraud is closely related to national law.

Despite this, this overview of some of the definitions of food fraud from academic literature is very helpful because it clarifies what food fraud is as mentioned in various articles and reports, including the RASFF reports, before the official definition of a fraud notification and the operative criteria to determine food fraud was created recently. This overview provides insights into the interpretation and significance in comprehending the concept of food fraud by offering a snapshot from academic literature:

- Spink and Moyer defined the term "food fraud" as an intentional and deliberate act of replacing, altering, or misrepresenting food, its ingredients, and packaging, or generally making false statements about a food product for financial benefit (Spink & Moyer, 2011).

- Everstine et al. (2013) simply described food fraud as the intentional adulteration of food for financial gain.

- Ellis et al. (2015) demonstrated that food fraud occurs when food is intentionally placed on the market for financial advantage to deceive consumers. Food fraud is called Economically Motivated Adulteration (EMA) in the United States and occasionally overseas. Two significant forms were stated: (i) trading food unfit for human consumption or harmful and (ii) intentionally mispresenting the food, including false assertions about the geographical origin or its components.

- In 2016, Manning, in his study, described food fraud as the deliberate misrepresentation of fact by an individual acting alone or on behalf of an organisation to persuade another individual to part with something of intrinsic value erroneously (Manning, 2016).

- Charlebois et al. (2016) stated that any intentional modification to a food product to deceive and profit financially constitutes food fraud.

- Food fraud is any illegal and intentional deceit for financial gain at any point in the food supply chain (Spink et al., 2017).

- Bouzembrak et al. (2018) stated that any case in which there is a breach of EU food law to gain an economic or financial advantage through consumer deception is a food fraud case. Furthermore, food fraud in the food supply chain can occur as a result of misrepresentation related to product integrity (for example, expiration date), process integrity (for example, diversion of products outside of intended markets), and data integrity (for example improper, expired, fraudulent, or missing health certificates).

- In the study of Manning and Soon in 2019, they described that food fraud is when food products or related documentation are intentionally changed for financial gain. And depending on the actions performed or the agent utilised, it might lead to concerns and issues of food safety, legality, and quality (Manning & Soon, 2019).

The four primary operational criteria given by the Directorate-General for Health and Food Safety to determine whether a case should be classified as suspicion of fraud or non-compliance by food business operators are highlighted in the definitions from the academic literature listed above. Predominantly, all definitions of food fraud mention deceit to customers, undue advantage (financial or economic benefit) for food business operators, and the intention of the food business operator, which is not coincidental.

1.7 Types of Food Fraud

Food fraud is characterized by deceptive practices that compromise the quality, and/or safety, and/or authenticity of food products. These deceitful practices weaken customer trust and affect food supply chain integrity. It includes a variety of fraudulent practices, such as ingredient substitution, mislabelling, adulteration, counterfeit products, imitation packaging, and falsified expiration dates. Definitions for the various types of food fraud from academic literature are given below:

- Adulteration and tampering of the product include the acts of introducing a foreign material or element of lesser value into the product (addition), using less valuable ingredients to replace or substitute a more precious ingredient or component (substitution), and using unapproved ingredients or failing to declare a substance used to enhance the organoleptic properties or mask an undesirable trait of a food product (unapproved/undeclared enhancement and concealment) (Tola, 2018; Visciano & Schirone, 2021). Visciano & Schirone (2021) also added that using water or another solvent to dilute a product in such a way that the product's quality decreases (dilution),

applying unapproved or undeclared methods to treat or process food, such as adding unapproved preservatives (unapproved/undeclared treatment, process, or product) or removing a natural constituent from a food (removal) constitutes adulteration and tampering of a food product.

- Counterfeiting refers to the copying or recreating of an original agri-food product or its packaging, such as imitating the brand name, packaging design, or processing method (Haji et al., 2022; Sandakova & Motina, 2021; Visciano & Schirone, 2021). Counterfeiting is usually done for financial gain and constitutes an infringement of intellectual property rights (IPR). In this case, there might be legal repercussions, predominantly through economic sanctions such as fines.

- Forging documents is creating, altering, or imitating official documents such as certificates of origin, business licenses, product registration records, inspection certificates, test results from analytical procedures, compliance declarations, and administrative records (Li et al., 2022). Forging documents is unethical and may have legal repercussions such as criminal (imprisonment) and economic sanctions (fines).

- Grey market activities refer to the unauthorized diversion, theft, and production occurring within unapproved agricultural product sales channels (JRC, 2023). These activities pose a challenge to traceability, which is crucial for ensuring the safety and quality of food products.

- Mislabelling (including misdescribing and misbranding) is the act of putting misleading information on the label or package, including false claims about quality, quantity, authenticity, expiration date, manufacture date, health, nutrition, and geography (Bimbo et al., 2019; JRC, 2023; Visciano & Schirone, 2021).

1.8 Impact of Food Fraud

Food fraud is a global issue becoming more frequent, with countless occurrences documented in recent years. Experts have determined that 1% of the global food industry is affected by food fraud (FDA, 2023). Therefore, to maintain a safe and sustainable food supply for everybody, the issue of food fraud must be addressed holistically.

Firstly, food fraud can have a massive impact on food industries. Food fraud results in financial losses, product recalls, litigations, and a loss of consumer trust. The cost of recalls and damage to brand reputation can be enormous, as witnessed in the 2013 horsemeat

scandal in Europe. In January 2013, the horsemeat scandal emerged when the Food Safety Authority of Ireland conducted routine tests and discovered the presence of horsemeat in beef meat products sold in the retail and food service markets of the United Kingdom (UK) and Ireland. Further testing revealed that horse DNA was detected in 37% of beef burgers purchased from popular food retail stores. The adulteration occurred in beef products sourced from three meat plants in the UK and Ireland. In February 2013, additional reports from UK company Findus and retailers Aldi and Tesco confirmed the presence of horsemeat in their lasagne, spaghetti bolognese, burger, and meatball products (Brooks et al., 2017). The scandal resulted in considerable financial losses for the businesses involved (Montanari et al., 2016). Also, it decreased consumer confidence and trust in the food industry, resulting in reduced commerce (Spink et al., 2015).

Moreover, the most critical issue is the impact of food fraud on consumer health and safety. Food fraud can include harmful substances that endanger human health, such as undeclared allergies, industrial chemicals, and unapproved preservatives. The harm to the consumer and public health can be enormous, as witnessed in the 2008 Chinese milk scandal. Melamine was added to milk to increase its protein content, as measured by nitrogen levels, to meet China's national standard for milk protein (Wen et al., 2016). This deceptive practice affected approximately 294,000 children who suffered melamine-related urinary stones, of which 51,900 were hospitalised, with 6 deaths (Wang et al., 2011). All affected infants had consumed formula milk powder primarily produced by Sanlu, a Chinese company. Some samples from this company showed extremely high levels of melamine, reaching up to 2,563 mg/kg. The subsequent nationwide screening revealed that more than 20 dairy companies had engaged in similar illegal practices to deceive government quality control measures (Wen et al., 2016). Likewise, food mislabelling can result in customers accidentally consuming foods they are allergic to or consuming foods they should avoid for religious, clinical, or ethical reasons, which can have serious health or religious effects (Moreira et al., 2021).

Lastly, food fraud has a huge economic impact. Fraudulent business activities can cause trade distortions and unfair competition. Mislabelling a cheap fish as more costly, for example, can cause market distortions because the fish's true market value is not reflected in its price (Kappel & Schröder, 2016). Mislabelling can lead to unfair competition, and legitimate producers may be forced out of the market. According to the United States Food and Drug Administration, the global economic impact of food fraud is $10–$15 billion

annually. However, more recent estimates from industry experts suggest a cost of around $40 billion annually (FDA, 2023).

1.9 Drivers of Food Fraud (Food Fraud Vulnerability)

Vulnerability to food fraud is a complicated problem caused by several interconnected factors. According to van Ruth et al. (2017), market demand, pricing, complexity, globalisation, legislation, and criminal history are all factors that make the food industry vulnerable to committing fraudulent activities.

To start with, as the market demand for certain food products increases due to changes in the preferences of consumers, a food industry might adopt certain practices or activities to fulfil the increased demand and maximise its profit. Such activities could involve adulterating or mislabelling products to meet the demand and preferences of consumers. The study conducted by Jacquet and Pauly (2008) found instances of mislabelling in the seafood industry. Seafood products were mislabelled as environmentally safe and sustainable to appeal to the increasing demand for eco-friendly seafood products.

Additionally, some food business operators or industries may commit fraud to maintain profits. An example is diluting products or substituting costly ingredients with cheaper ones (Spink & Moyer, 2011) when the cost of ingredients, materials, or production rises. This fraud leads to consumers buying a high-priced yet low-quality product. This situation is especially true for expensive foods, for example, the case of caviar, where salted caviar is replaced with pasteurised caviar which has less economic and culinary value (Black et al., 2016). Moreover, some producers may use deceptive labels or packaging to make their products appear more expensive to deceive people into paying more than what the product is worth (Messer et al., 2017).

Furthermore, the globalization and complexity of the food supply chain are drivers of food fraud. It is becoming more difficult to trace the origin of food products and detect fraud as the food supply chain gets more complex and globalised (Ellis et al., 2015). This is especially true when the food product has been processed or packaged several times before reaching the final customer (Spink, 2019). The complexity of the supply chain can further enhance the potential for intentional or unintentional contamination of food products (Ling & Wahab, 2020).

Finally, regulations and standards also influence food fraud vulnerability. Inadequate or insufficient regulation and standards can open the door to fraud. The lack of enforcement, weak regulations, minimal surveillance, and ineffective monitoring and investigation systems can foster an environment where food business operators or industries feel more comfortable engaging in food fraud (Smith et al., 2022). Therefore, regulatory frameworks greatly influence the degree of food fraud vulnerability.

These factors most often operate together rather than independently. For example, rising market demand for a specific food supply offers financial incentives for fraudsters to exploit. Moreover, it is difficult to identify and stop fraudulent actions because of the complexity of food supply chains.

1.10 The Rapid Alert System for Food and Feed (RASFF)

The RASFF is an EU system or tool designed to facilitate the rapid exchange of information between EU Member States and the European Commission regarding human and animal health risks related to food and feed products. It is a tool that allows for quick communication and coordination to address and manage food safety incidents effectively (Somorin et al., 2021).

The RASFF, as it is now, was established in 2002 by Regulation (EC) No 178/2002 (Article 50) to serve as a system for notifying direct or indirect risks to human health derived from food or feed. The members of the RASFF network involve a contact point designated by each EU Member State, the European Commission, and the EFSA, and the responsibility of managing this network lies with the European Commission.

When a Member State detects a potential food safety issue within its territory, it issues a notification to the RASFF. The food safety issue can include concerns about food fraud, contamination, allergens, chemical residues, and heavy metals, among other risks. The RASFF shares this notification with all EU Member States and the European Commission in real time through its secure online platform. All Member States and the European Commission can then assess the information of the notification and take appropriate measures to address the situation. These measures can include product recalls, import bans, and heightened inspections. When relevant updates and developments are established, they are also shared promptly in the RASFF to facilitate continuous communication between the Member States and the European Commission during the entire process.

Four types of notifications are shared in the RASFF: alert notifications (issued when a food or feed product that presents a risk to health is identified on the market and rapid actions to withdraw the product from the market are required, such as cases involving contamination, pathogens or toxins), information notifications (issued as attention or follow-up when a food or feed product that presents a potential risk is identified on the market, such as wrong labelling or unauthorized use of additives), border rejections (issued when a food or feed product is refused entry at the EU Member State's border due to non-compliance with safety standards or improper documentation) and news (any unclassified notification, neither as alert nor information notification, issued in relation to food or feed safety which can be of interest to relevant authorities) (Pigłowski, 2017).

The RASFF is a crucial mechanism that continues to enhance food safety across the EU. It enables fast communication so that rapid actions can be taken when there are food or feed-related risks to human and animal health.

CHAPTER 2

OBJECTIVE

The main objective of this study is to provide a comprehensive overview of food fraud reported in the RASFF. By analyzing the data reported in the RASFF, this study aims to identify patterns and trends in food fraud cases, including the types of fraudulent activities, the products most affected, the countries most affected, the common origins of fraudulent food products, and the prevalent detection method. Gaining a comprehensive understanding of the patterns and variations of food fraud is crucial for enhancing food control systems and strengthening deterrence mechanisms. This information will enable authorities to develop targeted strategies and regulations, if necessary, to mitigate the risks associated with food fraud, ultimately safeguarding consumer health and confidence in the food supply chain.

Overall, the study seeks to:

- Analyse the pattern and trends of food fraud and adulteration cases reported in the RASFF.

CHAPTER 3

MATERIALS AND METHODS

This chapter outlines the materials and methods employed in the research study.

3.1 Study Design

The study will adopt a retrospective longitudinal study design, examining previously collected data from online databases and published annual reports. The goal of using this study design is to contextualise the research findings within a broader timeframe spanning a more extended period. This approach will provide a comprehensive understanding of the subject matter by investigating how the results have varied and evolved throughout different reporting years. By evaluating these variances, the study will be able to find the trends, patterns, or changes that may have occurred through time.

3.2 Data Sources and Collection

Data will be collected from a secondary data source: the RASFF notifications 2021 and pre-2021 public information datasets which will be retrieved from the European Data Portal (EC, Directorate-General for Health and Food Safety, 2021). The study will not include RASFF notifications from 2022 because in 2021, the AAC system, regulated by Commission Implementing Regulation (EU) 2019/1715, replaced the RASFF as the system for reporting food fraud. The AAC system is exclusively accessible to Member States' authorities and the European Commission, so reports on food fraud after 2021 are not opened to the public (EC, Directorate General for Health and Food Safety, 2023). However, there is an ACN annual report for 2022 that reported on food fraud. Yet, the data presented are not adequate to be included in the analysis of this study since the ACN report only provides just a summary of the data on food fraud.

The RASFF datasets contain the yearly notifications and cases from the online RASFF database. The online RASFF database is the EU's repository for data on food and feed safety, including reports on food fraud activities and adulterated food products. Specifically, the "fraud/adulteration" hazard category will be used as the search criterion to identify relevant food fraud cases in the EU. The data extraction procedure will entail extracting all cases recorded in the RASFF datasets from 2005 to 2021. Data will be gathered on the frequency of food fraud cases, the type of food fraud, the food product categories reported in the food

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fraud cases, the EU Member States affected, the origin of food products, and detection methods.

3.3 Data Analysis

Once the relevant data have been collected from the above sources, the collected data will be subjected to a series of analyses to identify the trends and patterns of food fraud. The data analysis will involve the following steps:

- Data cleaning and preprocessing. Once the appropriate data has been gathered from the aforementioned sources, it will be thoroughly reviewed and cleansed to ensure its quality, usability, and reliability. Furthermore, data formats will be standardised, putting data into a unified structure, for example, aligning dates to a specified form. This will aid in establishing consistency and uniformity, allowing for smooth integration across variables. Furthermore, strict data validation techniques will be used to ensure data accuracy.

- Data coding and categorisation. The cleaned and preprocessed data will be categorised and coded using important variables such as the type of food fraud and product category. This systematic coding and categorising will allow for an organised and structured data analysis, allowing for a thorough comprehension of the underlying findings. This approach will make it easy to explore the dataset and draw useful conclusions. The coding and categorising process will aid in the systematic analysis of the collected data.

- Descriptive analysis. Once the data has been coded and categorised, a descriptive analysis will be performed to determine the trends and patterns of food fraud in Europe. Descriptive statistical methods will be used to summarise the data gathered, allowing for a concise representation of the findings. The analysis includes investigations such as the frequency of food fraud incidents, the specific types of food fraud, and the most affected food products, all aimed at presenting a comprehensive overview of the prevalence and magnitude of food fraud across the EU over the years. Tableau and Excel statistical software will be used to conduct the analysis. Furthermore, visual aids such as charts and graphs will be used to provide a better understanding of the data.

3.4 Ethical Considerations

The study will adhere to the principles of data privacy and confidentiality. The study will examine data gathered from official reports and databases that are freely available to the public. It will strictly comply with the regulations and guidelines governing the use of such public data sources. No human participants are actively involved in the study, and all data used will be anonymised and aggregated, if necessary, to protect privacy and confidentiality.

3.5 Limitations of the Study

It is essential to acknowledge the limitations associated with this study. First, the analysis is based on publicly available data sources, which may not capture the full scope of food fraud incidents due to factors such as underreporting, lack of data availability, and inconsistencies. Second, the data's accuracy and reliability depend on the reporting mechanisms and practices of the respective organisations involved. Third, the study focuses primarily on documented food fraud cases, potentially overlooking emerging or unrecorded fraudulent activities. Finally, the study is focused on the EU and countries that are part of the RASFF and the findings may not be generalisable to other regions.

Despite these limitations, the findings of this study will provide valuable insights into the trends and patterns of food fraud in the EU.

3.6 Summary of Methods and Materials

In summary, this chapter describes the materials and methods that will be adopted in the study to investigate the trends and patterns of food fraud. The data collection process will involve extracting relevant information from the public RASFF annual reports. The collected data will be analysed using various descriptive statistical techniques to identify the trends and patterns of food fraud. Ethical considerations will be adhered to throughout the study process, and the limitation of the study is acknowledged.

The subsequent chapter will present the results and findings of the study.

CHAPTER 4

RESULTS

This chapter presents the results from the analyses of the data to address the research objectives. The data was downloaded from the RASFF database from 2005 to 2021. The subsequent sections give the presentation of the results.

4.1 Prevalent Types of Food Fraud

A total of 2031 food fraud and adulteration cases were reported (notified) in the RASFF database from 2005-2021. The reported food fraud cases were categorised into the five types of food fraud given by the Directorate-General for Health and Food Safety, namely: (i) adulteration and tampering, (ii) counterfeiting, (iii)forging documents, (iv) grey market activities and (v) mislabelling. The most common type of food fraud during the study period was the forging of documents (53.27%, n=1082). Grey market activities accounted for 33.68% of the cases (n=684). In addition, adulteration and tampering, mislabelling, and counterfeiting accounted for the rest of the cases, with 9.21% (n=187), 3.69% (n=75), and 0.15% (n=3), respectively, as presented in Figure 1.
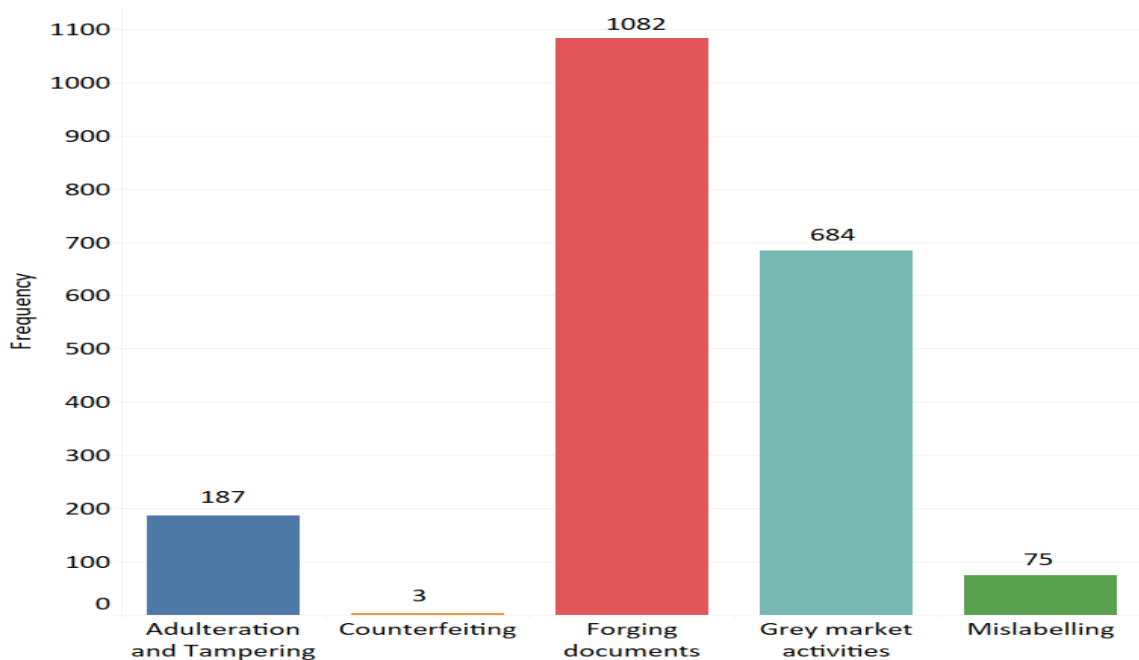

Figure 1: Distribution of the types of food fraud across the study period.

For this study, the common methods of food fraud reported in the RASFF database from 2005-2021 were categorised as follows:

- Adulteration and Tampering: (i) adulteration (n=151), (ii) decontamination products (unauthorised use) (n=1), (iii) illegal use (of animal by-products for production) (n=2), (iv) monoethylene glycol (MEG) (presence) (n=6), (v) paraffin (coating, presence) (n=23), (vi) pufferfish (Tetraodontidae) (presence among other fishes) (n=1) and (vii) tampering (n=3).

- Counterfeiting: (i) counterfeit (n=3).

- Forging documents: (i) certified analytical report (absence, improper) (n=158), (ii) common health entry document (CHED) (absence, improper, fraudulent) (n=51), (iii) health certificate (absent, expired, fraudulent, improper, suspicion) (n=831), (iv) import declaration (missing, improper) (n=41) and (v) take-over declaration (fraudulent) (n=1).

- Grey market activities: (i) export (fraudulent) (n=1), (ii) illegal trade (n=26), (iii) import (unauthorised, illegal import including suspicions and attempts) (n=433), (iv) offered online for sale (unauthorised) (n=14), (v) transit (unauthorised) (n=25) and (vi) unauthorised placing on the market (n=185).

- Mislabelling: (i) fraud (fake labelling, wrong labelling, false documentation of product) (n=63), (ii) fraudulent use of health mark (n=7), and (iii) origin unclear (n=5).

4.2 Common Food Fraud Methods and Their Trends

The most prevalent food fraud methods of 1031 cases employed by food business operators or industries were absence/expired/fraudulent/improper health certificate (40.92%, n=831), unauthorised/illegal import (21.32%, n=433), unauthorised placing on the market (9.11%, n=185), absence/improper certified analytical report (7.78%, n=158) and adulteration (7.43%, n=151). The least employed food fraud methods were unauthorised use of decontamination products, fraudulent export, presence of pufferfish among other fishes, and fraudulent take-over declaration (0.05%, n=1 each), as presented Table 1.

Overall, from Figure 2, methods of food fraud observed an increasing trend across the years with a series of fluctuations. The highest peaks were observed in 2013 and 2017. Certified analytical reports (absence/improper), common health entry documents (absence/improper/fraudulent), and health certificates (absence/improper/fraudulent/

improper/suspicious) averagely recorded an increasing trend with significant fluctuations across the years. These methods of food fraud had their highest peak in 2017, and it is worth noting that the fluctuations occurred on average every two years. On the other hand, fraud (fake labelling, wrong labelling, false documentation of product) recorded a decreasing trend across the years with fluctuations on average every three years.

Moreover, transit (unauthorised) and illegal trade experienced a surge in the short term, but it declined sharply and eventually reached zero in the subsequent years, whiles paraffin (coating, presence) experienced a consistent baseline of zero over several years and chalked a sudden peak in 2021. Furthermore, import (unauthorised, illegal including suspicions and attempt) experienced a modest upward trend, whereas unauthorised placing on the market experienced a modest downward trend. Finally, the other methods of food fraud with less than 14 cases showed either a stable increase, decrease, marginal increase or marginal decrease across the years, while adulteration (n=158) and import declaration (missing, improper) (n=41) were stable across the years as presented in Figure 2.

Table 1: Distribution of food fraud methods, 2005-2021.

| Food Fraud Methods (Substance/Finding of Notification)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Adulteration			1			1	6	1	138	2					1	1		151
Certified analytical report (absence, improper)		1	4	1			2	3	12	7	8	14	56	13	21	10	6	158
Common health entry document (CHED) (absence, improper, fraudulent)							4	1	1	8	5	4	13	4	1	8	2	51
Counterfeit								3										3
Decontamination products (unauthorised use)				1														1
Export (fraudulent)																1		1
Fraud (fake labelling, wrong labelling, false documentation of product)	3	15	2	4	7	3	4	9	7		1		2	3		1	2	63
Fraudulent use of health mark			1	1	2	1	1				1							7
Health certificate (absent, expired, fraudulent, improper, suspicion)		16	32	30	52	44	57	54	64	50	60	83	109	52	55	28	45	831
Illegal trade	7	12	3		2		1				1							26
Illegal use (of animal by-products for production)		1		1														2
Import (unauthorised, illegal import including suspicions and attempts)	27	30	28	20	15	27	24	15	14	26	20	30	50	20	44	35	8	433
Import declaration (missing, improper)							22	3	3	4	5			1			3	41
Monoethylene glycol (MEG) (presence)	1	1						1		1		1		1				6
Offered online for sale (unauthorised)															5	5	4	14
Origin unclear			1		1								3					5
Paraffin (coating, presence)		1	2														20	23
Pufferfish (Tetraodontidae) (presence among other fishes)												1						1
Take-over declaration (fraudulent)			1															1
Tampering							1	2										3
Transit (unauthorised)	13	1	1		3	7												25
Unauthorised placing on the market		21	17	6	7	4	12	7	36	21	10	8	4	6	8	11	7	185
Total	51	99	93	64	89	87	137	96	275	119	112	143	234	100	135	100	97	2031
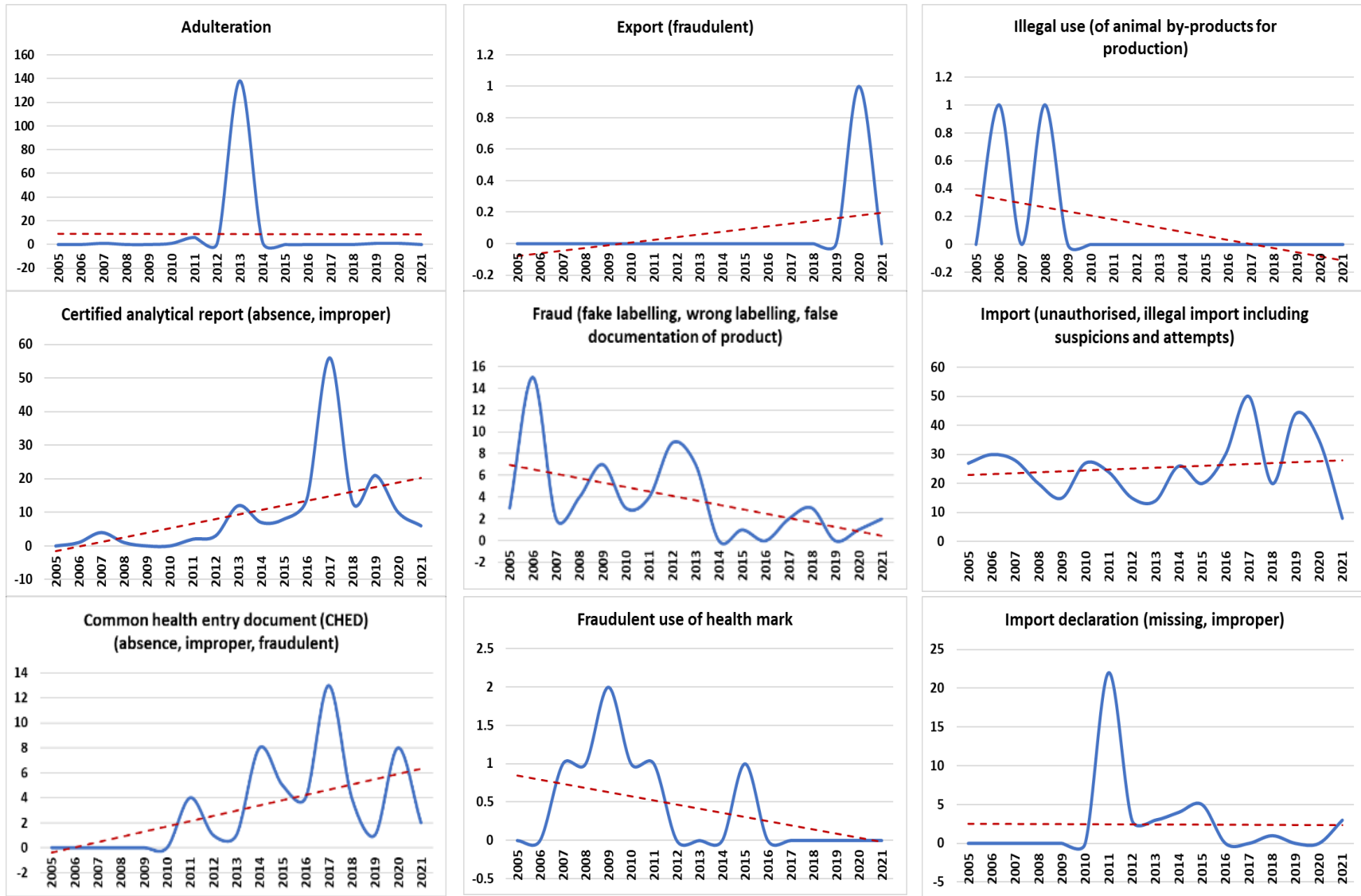
Figure 2: Illustration of food fraud methods trends, 2005-2021.
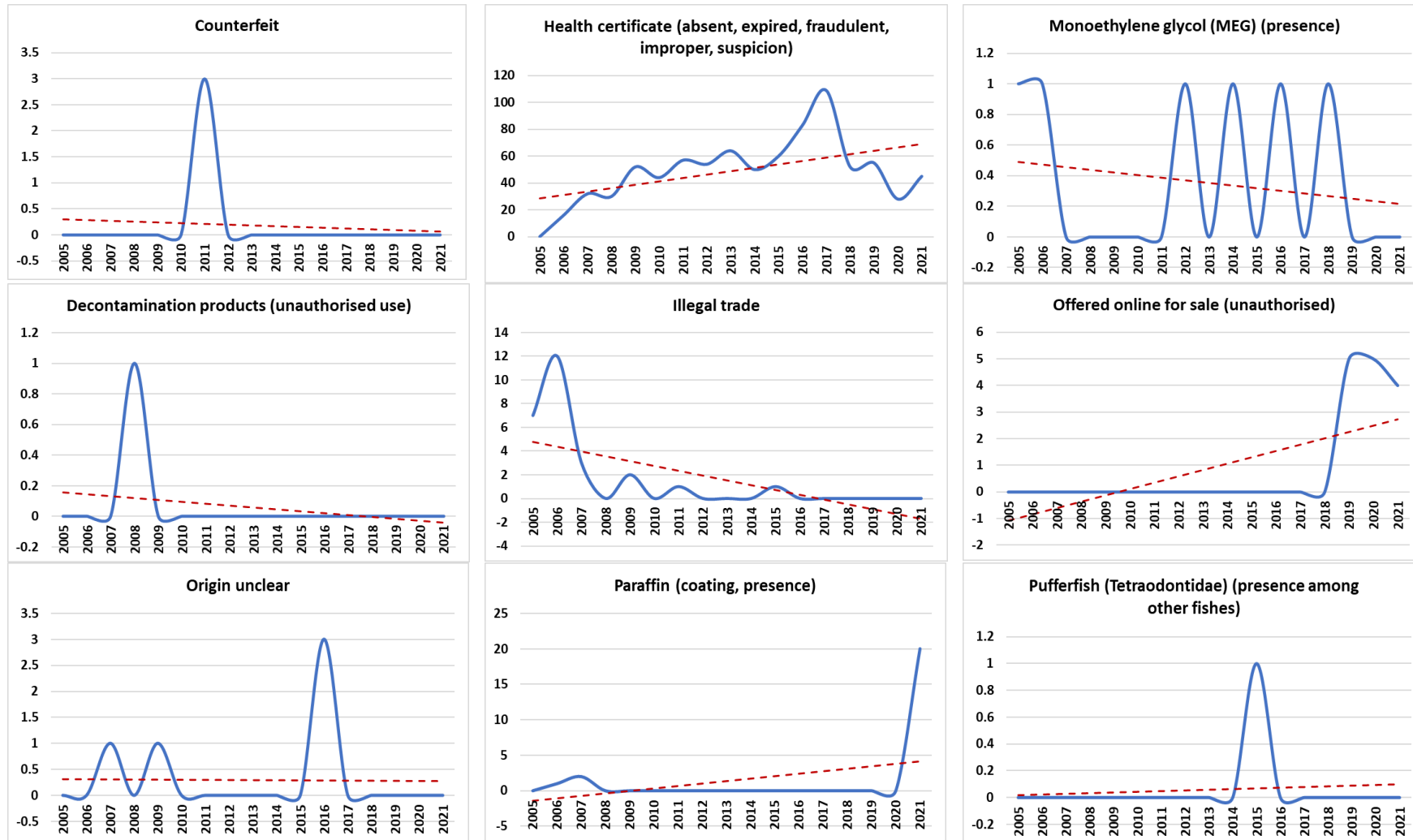
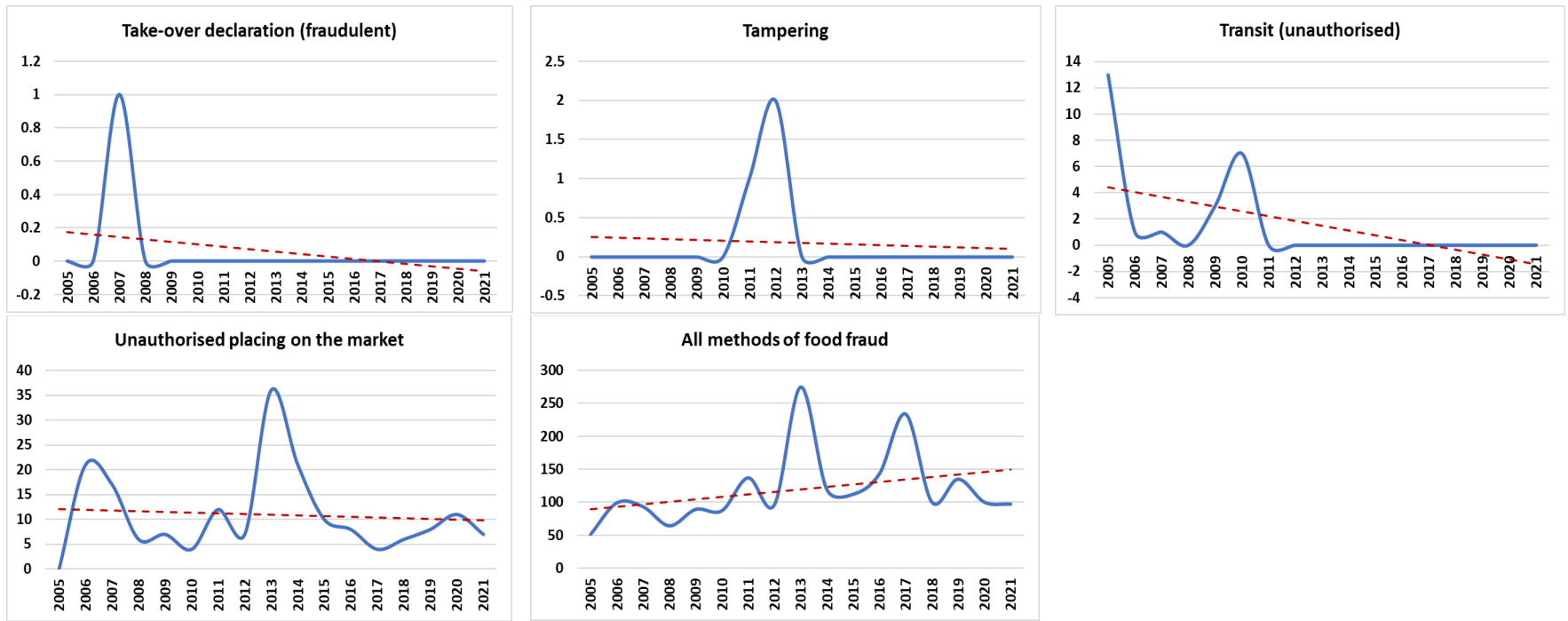Figure 2: Illustration of food fraud methods trends, 2005-2021 (continued 1)

Figure 2: Illustration of food fraud methods trends, 2005-2021 (continued 2)

4.3 Food Product Categories Most Vulnerable to Food Fraud and Their Trends

Overall, nuts, nut products and seeds observed the highest number of food fraud cases (22.01%, 447 out of 2031 cases), followed by fruits and vegetables (10.49%, 213 out of 2031 cases), meat and meat products (other than poultry) (10.44%, 212 out of 2031) and fish and fish products (9.50%, 193 out of 2031). On the other hand, food contact materials (0.05%, 1 out of 2031 cases), ices and deserts (0.05%, 1 out of 2031 cases), wine (0.15%, 3 out of 2031 cases), alcoholic beverages (0.30%, 6 out of 2031 cases), non-alcoholic beverages (0.34%, 7 out of 2031 cases), natural mineral water (0.34%, 7 out of 2031 cases) and food additives and flavourings (0.34%, 7 out of 2031 cases) observed the lowest number of cases, as presented in Table 3.

The food product categories associated with the highest number of adulteration and tampering activities were meat and meat products (other than poultry) (45.45%, 85 out of 187 cases) and prepared dishes and snacks (29.41%, 55 out of 187 cases). Moreover, nuts, nut products and seeds (36.32%, 393 out of 1082 cases) were associated with the highest number of activities involving forging of documents, followed by herbs and spices (11.55%, 125 out of 1082 cases), fruits and vegetables (10.72%, 116 out 1082 cases) and fish and fish products (10.35%, 112 out 1082 cases). Furthermore, grey market activities were most frequent for dietetic foods, food supplements and fortified foods (17.54%, 120 out of 684 cases), meat and meat products (other than poultry) (12.28%, 84 out of 684 cases), fruits and vegetables (10.38%, 71 out of 684 cases) and fish and fish products (10.23%, 70 out of 684 cases). Finally, mislabelling was most frequent with meat and meat products (other than poultry) (18.67%, 14 out of 75 cases), other food product/mixed (10.67%, 814 out of 75 cases) and fish and fish products (10.67%, 14 out of 75 cases). All three counterfeiting cases were observed for soups, broths, sauces and condiments, as presented in Table 2.

Overall, there has been a rising trend in food products being subjected to fraud over the years, with some highs and lows. The highest peaks were seen in 2013 and 2017. Nuts, nut products and seeds, fish and fish products, and fruits and vegetables exhibited an upward trend with gradual fluctuations each subsequent year. Among these, nuts, nut products and seeds reached their highest peak in 2017, experienced a decrease in 2018, followed by a surge in 2019, and then underwent a rapid decline. Fruits and vegetables, on the other hand,

reached their highest peak in 2016, remained relatively stable in 2017, recorded a decline, and then saw a resurgence starting in 2020.

In contrast, meat and meat products (other than poultry) demonstrated a consistent downward trend over the years, while herbs and spices displayed a consistent upward trend. Both maintained a consistently low baseline throughout the years, but notable peaks were observed for meat and meat products (other than poultry) in 2013 and for herbs and spices in 2016, which continued to rise in 2017 before returning to the low baseline. Prepared dishes and snacks exhibited a relatively stable trend with minimal variation, except for a notable peak in 2013. Meanwhile, dietetic foods, food supplements, and fortified foods showed a marginal increasing trend over the years, as presented in Figure 3.

Table 2: Distribution of food product categories most vulnerable to each type of food fraud, 2005-2021.

Food Product Category	Adulteration and Tampering	Counterfeiting	Forging Documents	Grey Market Activities	Mislabelling	Total
Alcoholic beverages	2		4			6
Bivalve molluscs and products thereof			25	21		46
Cephalopods and products thereof			14	10	3	27
Cereals and bakery products	1		50	8	2	61
Cocoa and cocoa preparations, coffee and tea			17	31		48
Confectionery			36	4	4	44
Crustaceans and products thereof	2		28	9	1	40
Dietetic foods, food supplements, fortified foods	2		12	120	1	135
Eggs and egg products	2		6	13	3	24
Fats and oils			14	13	5	32
Fish and fish products	3		112	70	8	193
Food additives and flavourings			5	2		7
Food contact materials	1					1
Fruits and vegetables	20		116	71	6	213
Gastropods			1	1	1	3
Herbs and spices	1		125	16	1	143
Honey and royal jelly	2		11	4	3	20
Ices and desserts				1		1
Meat and meat products (other than poultry)	85		29	84	14	212
Milk and milk products	4		8	25	4	41
Natural mineral water			4	3		7
Non-alcoholic beverages			4	3		7
Nuts, nut products and seeds			393	53	1	447
Other food product / mixed	1		24	53	8	86
Poultry meat and poultry meat products	2		13	35	5	55
Prepared dishes and snacks	55		14	28	4	101
Soups, broths, sauces and condiments	1	3	17	6	1	28
Wine	3					3
Total	187	3	1082	684	75	2031

Table 3: Distribution of food product categories most vulnerable to food fraud, 2005-2021.

| Food Product Category	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Alcoholic beverages							3				1	1			1			6
Bivalve molluscs and products thereof		7	10	3	10	3		2	3			6				1	1	46
Cephalopods and products thereof			4		1	1	1		5			1	7	2	1	2	2	27
Cereals and bakery products		4			2	1	4	3	9	11	3	1	8	2	11		2	61
Cocoa and cocoa preparations, coffee and tea		4	6	4	6		8	3	1			1		3		7	5	48
Confectionery		1	5	2			5	18		1			5	2	2	2	1	44
Crustaceans and products thereof		3	4	1	2	10	2		2	1	1	1	2	3	4	1	3	40
Dietetic foods, food supplements, fortified foods		11	9	3	3	2	12	8	23	22	7	4	3	4	9	10	5	135
Eggs and egg products			2	1	3	5	2	3			3	1	2		2			24
Fats and oils		1	2	4	4	2	3	3	1	2	1		1	1	4	3		32
Fish and fish products		3	6	11	9	25	14	9	17	2	11	14	9	18	13	14	18	193
Food additives and flavourings					1		2									3	1	7
Food contact materials		1																1
Fruits and vegetables		2	2	2	5	1	14	3	11	30	15	35	33	6	6	19	29	213
Gastropods			1			1			1									3
Herbs and spices	1	6	1	1		2	1	1	6		6	28	51	18	10	7	4	143
Honey and royal jelly		1		1	1	2	6	2	1		1		1	3	1			20
Ices and desserts		1																1
Meat and meat products (other than poultry)	27	18	10	8	18	11	2	10	92	1	1	3	1	1	2	3	4	212
Milk and milk products	2	2	1	7	7	3	6	3	4			1	1		3	1		41
Natural mineral water		1	2				3										1	7
Non-alcoholic beverages					1	4			2									7
Nuts, nut products and seeds		4	16	5	9	8	30	20	37	32	47	44	86	24	55	19	11	447
Other food product / mixed	7	9	9	6	2	6	3	2	3	8	4	2	5	2	7	6	5	86
Poultry meat and poultry meat products	13	4	2	3	6	2	4	3		3		1	7	1	1	3	2	55
Prepared dishes and snacks		14		2			4	1	55	2	2	5	6	5	2		3	101
Soups, broths, sauces and condiments		1	1			1	4	1	2	4	2		7	2	3			28
Wine	1	1							1									3
Total	51	99	93	64	89	87	137	96	275	119	112	143	234	100	135	100	97	2031
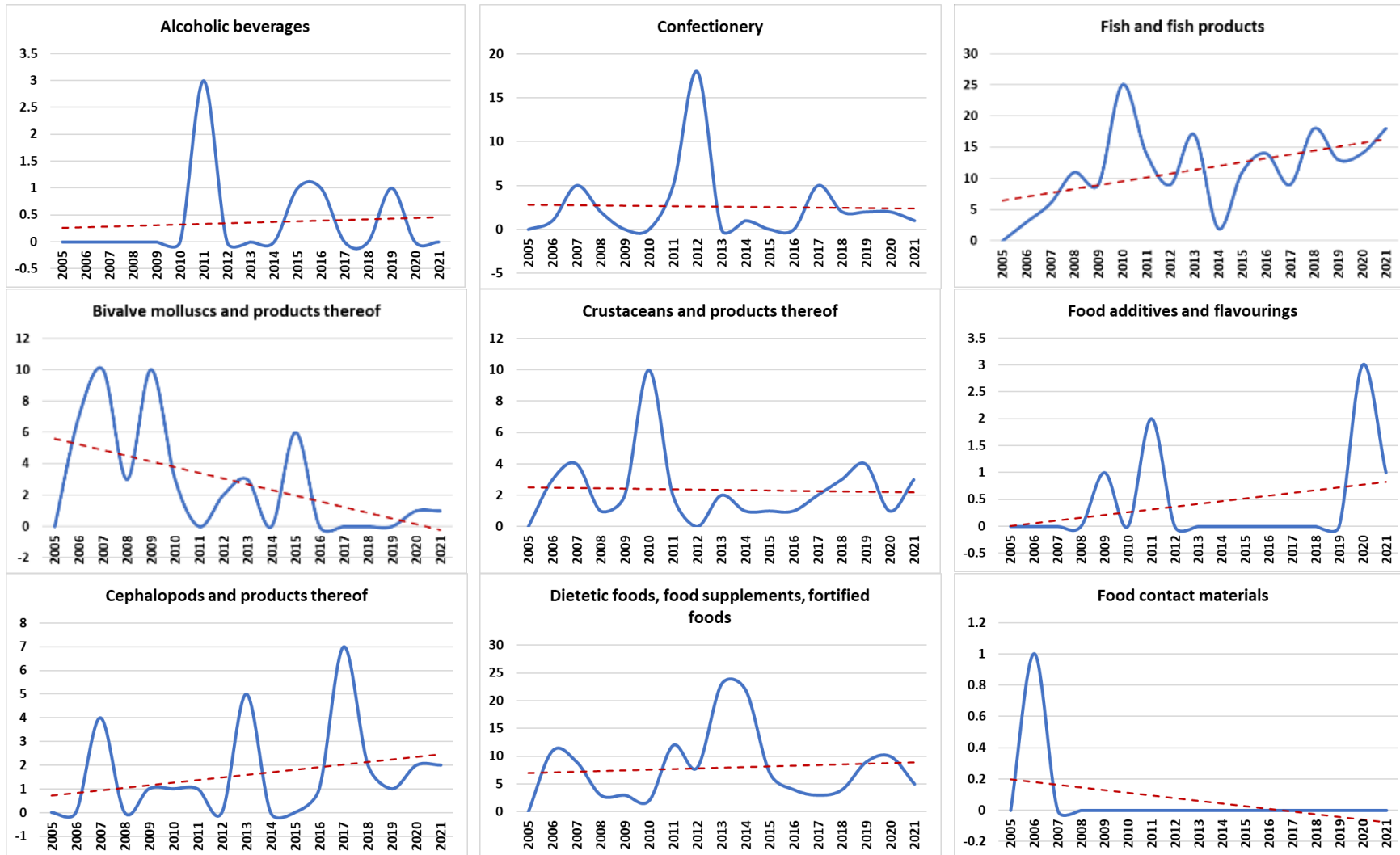
Figure 3: Illustration of food product categories most vulnerable to food fraud trends, 2005-2021.
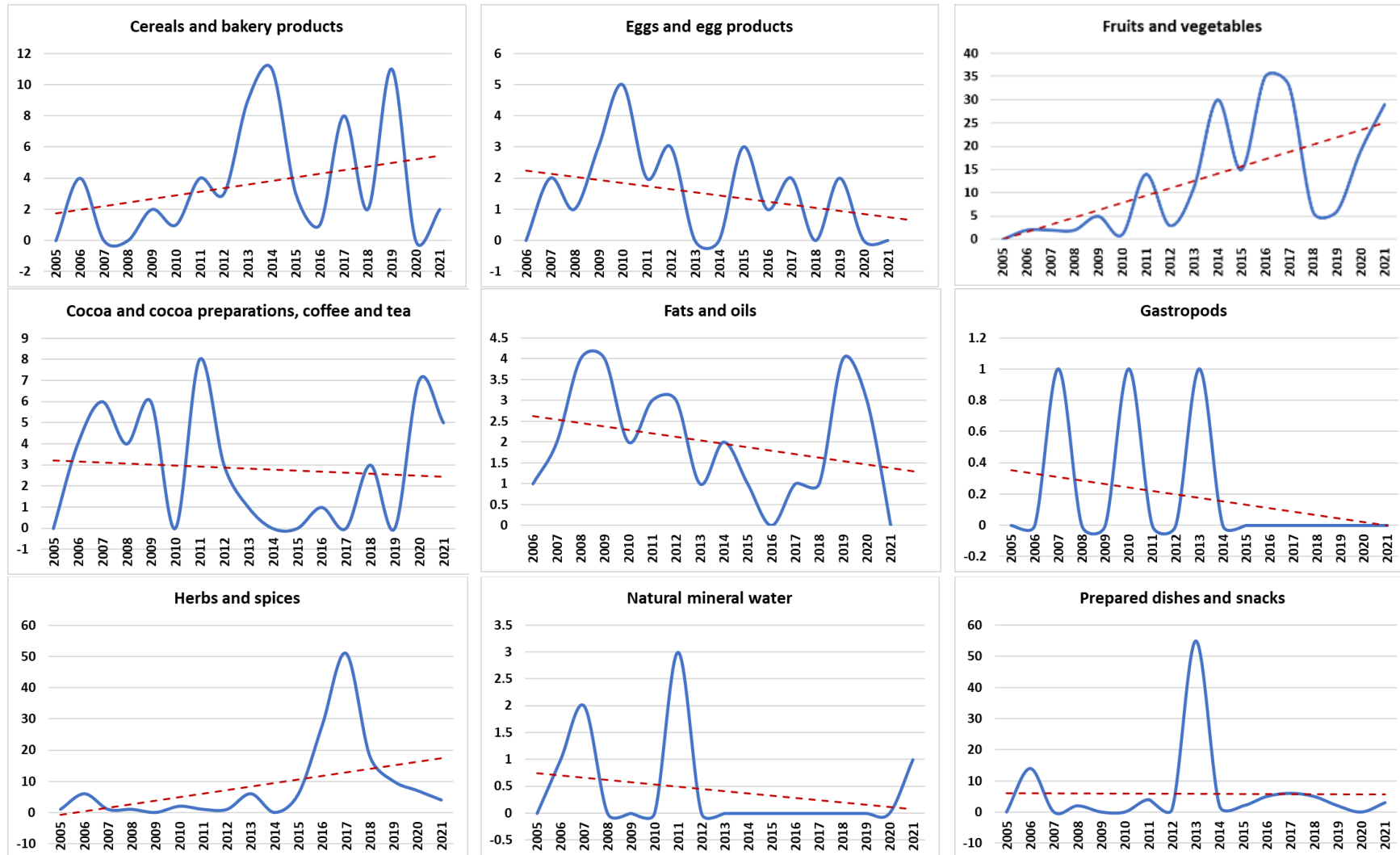
Figure 3: Illustration of food product categories most vulnerable to food fraud trends, 2005-2021 (continued 1).
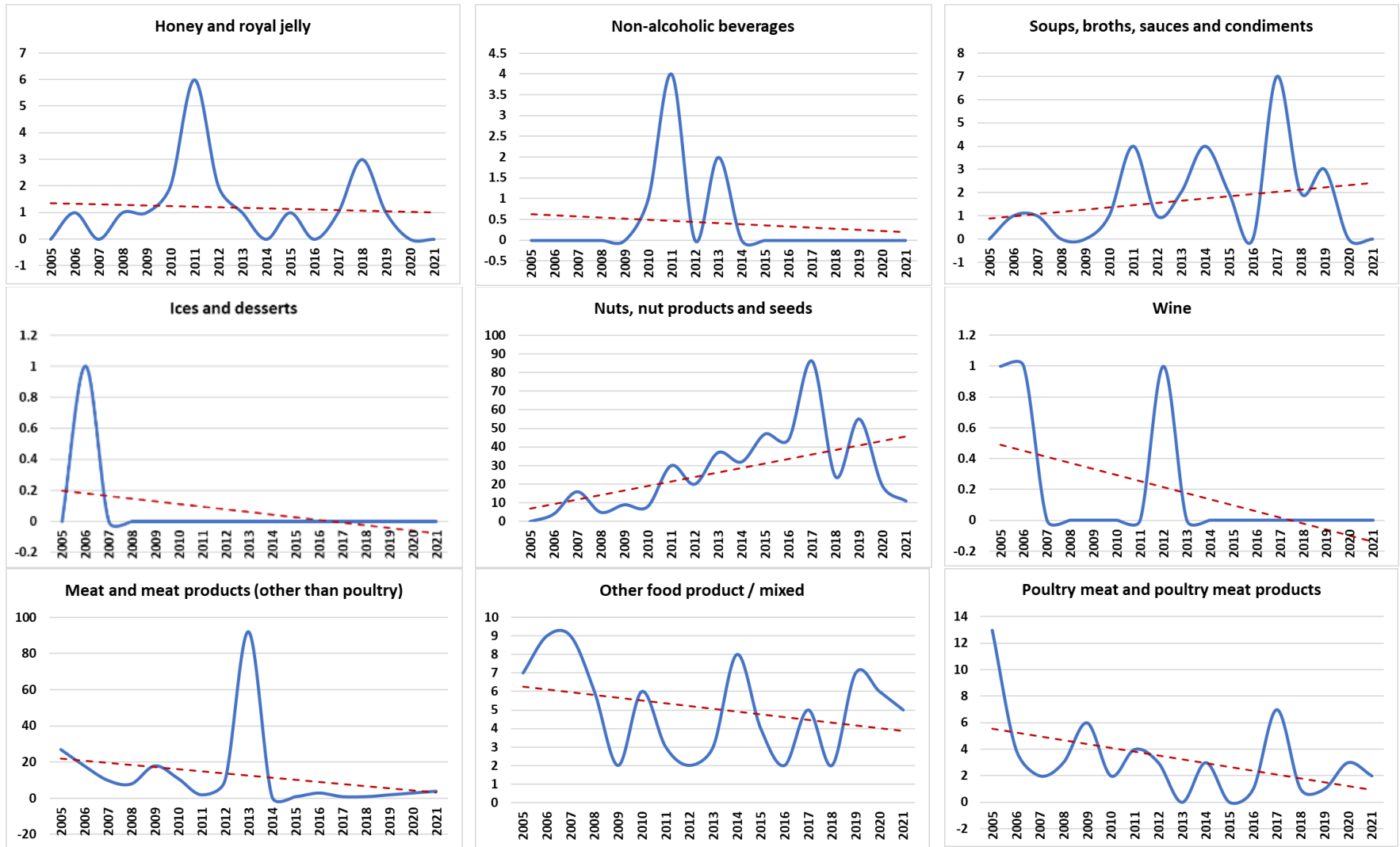
Figure 3: Illustration of food product categories most vulnerable to food fraud trends, 2005-2021 (continued 2).
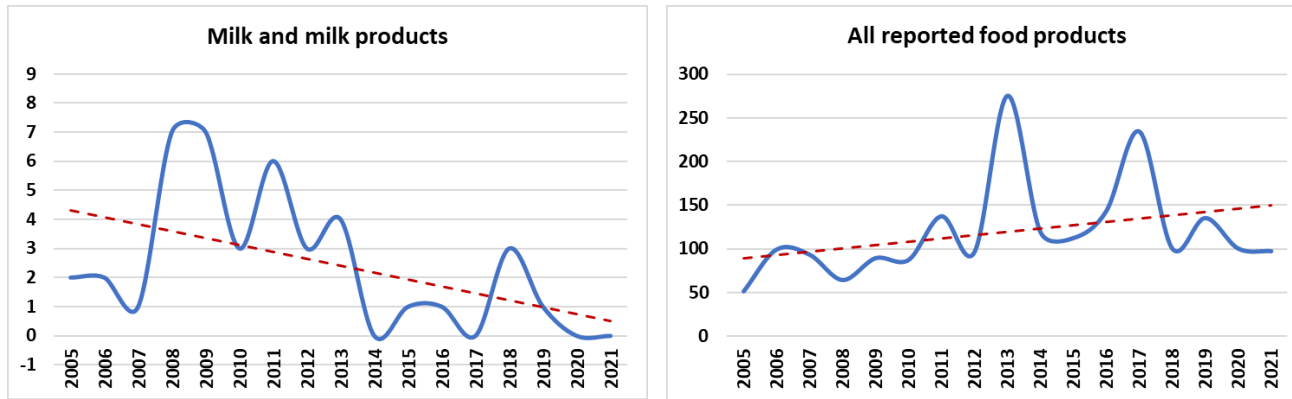
Figure 3: Illustration of food product categories most vulnerable to food fraud trends, 2005-2021 (continued 3).

4.4 Countries Most Affected by Food Fraud (Hotspot Countries)

Food fraud was widely distributed across various countries, including the EU Member States, the United Kingdom, Iceland, Norway, and Switzerland. The prevalence of food fraud varied, with some countries experiencing higher numbers than others. Notably, the United Kingdom, which was part of the EU until January 2021, reported the highest number of food fraud cases across the study period (31.76%, 645 out of 2031 cases). The United Kingdom was followed closely by Italy (9.01%, 183 out of 2031 cases), Spain (8.07%, 164 out of 2031 cases), Germany (5.81%, 118 out of 2031 cases), and France (5.22%, 106 out of 2031 cases). In fact, these five countries collectively accounted for half of all food fraud cases reported in the RASFF, amounting to 1216 out of 2031 cases (59.87%), as presented in Figure 4.
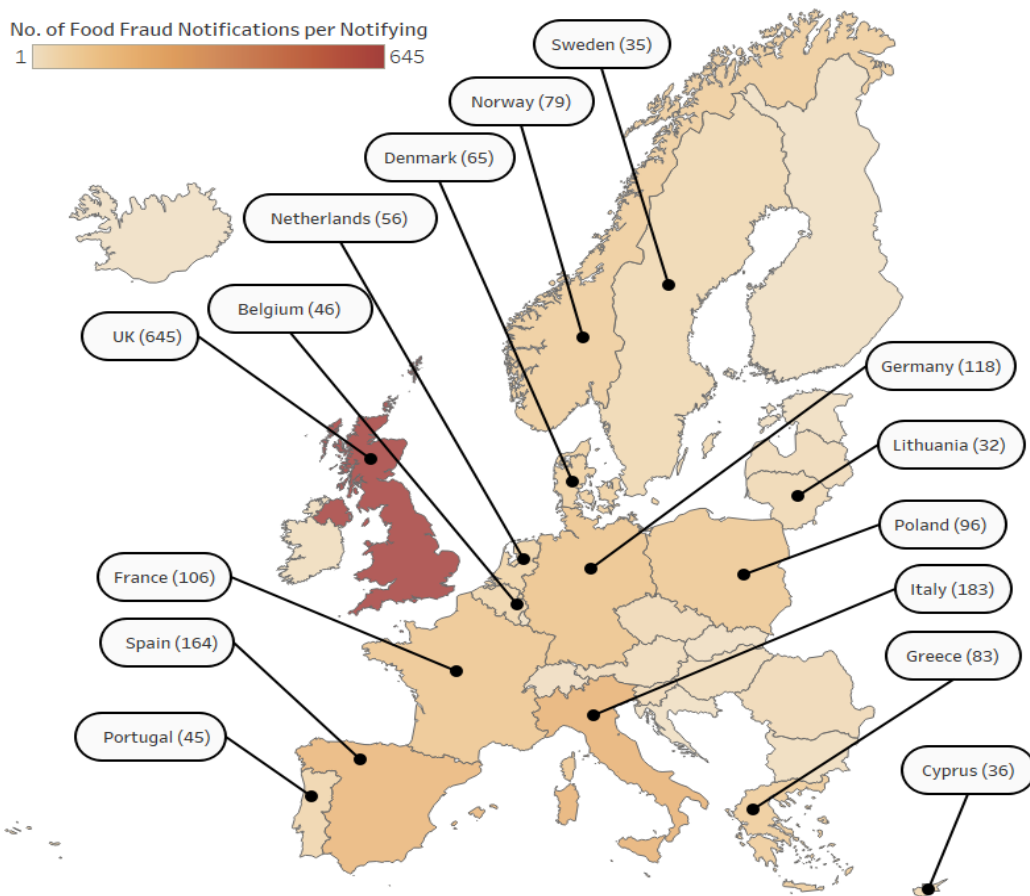

Figure 4: Geographical map of countries affected by food fraud, 2005-2021.

Note: Only countries with n>30 cases have their names presented on the map.

4.5 Origin of Food Products Reported in Food Fraud Cases

There was a diverse range of contributions from different continents, painting a comprehensive picture of the prevalence of food fraud worldwide. Asia was mostly cited for food fraud activities, accounting for 44.66% (n=907) of the reported cases. Europe follows Asia with 28.75% (n=584) of the reported cases. In contrast, Africa, North America and South America had relatively lower proportions of 14.67% (n=298), 5.71% (n=116) and 5.12% (n=104) of the reported cases, respectively. Finally, a small fraction of reported cases (0.69%, n=14) had unknown or unspecified origins, as presented in Figure 5.
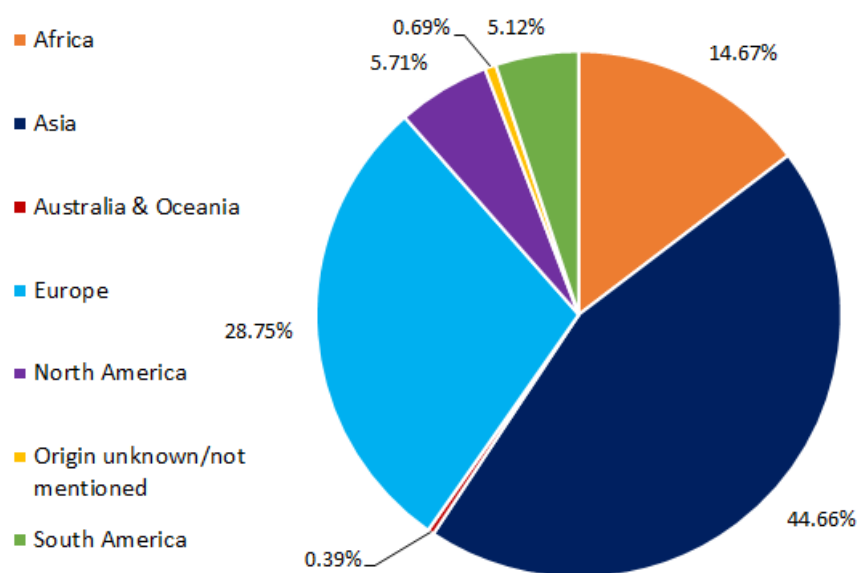

Figure 5: Distribution of food products reported in food fraud cases according to their continents of origin.

The origin of food fraud was distributed globally. Some countries recorded high rates of reports as being the origin of food products reported in food fraud cases compared to others. Notably, the highest number of food products were from China (16.94%, 344 out of 2031 cases). Followed closely by India (11.96%, 243 out of 2031 cases), Turkey (9.01%, 183 out of 2031 cases), Nigeria (4.78%, 97 out of 2031 cases), Ghana (4.23%, 86 out of 2031 cases) and the United States (3.74%, 76 out of 2031 cases). In fact, these six countries together contributed as the origin of half of all food fraud cases reported in the RASFF. This equated to 1029 out of 2031 food fraud cases (50.66%), as presented in Figure 6.
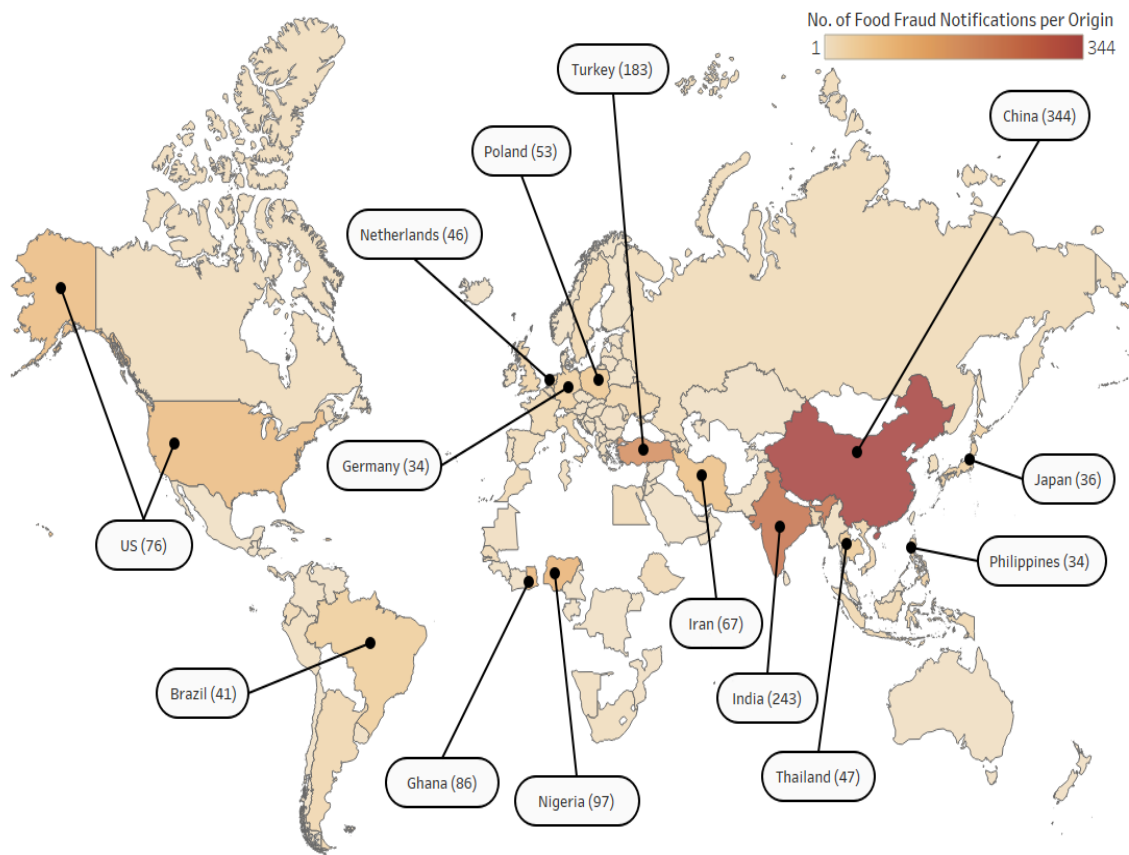
Figure 6: Geographical map of food products reported in food fraud cases according to their countries of origin.

Note: Only countries with n>30 cases have their names presented on the map. Countries not reported as the origin of food fraud do not appear on the map.

Out of Europe's 28.75% (n=584) share as origin of food products implicated in food fraud, EU Member States contributed as origin in 57% of cases. The non-EU Member States contributed as origin in 43% of cases, as presented in Figure 7.
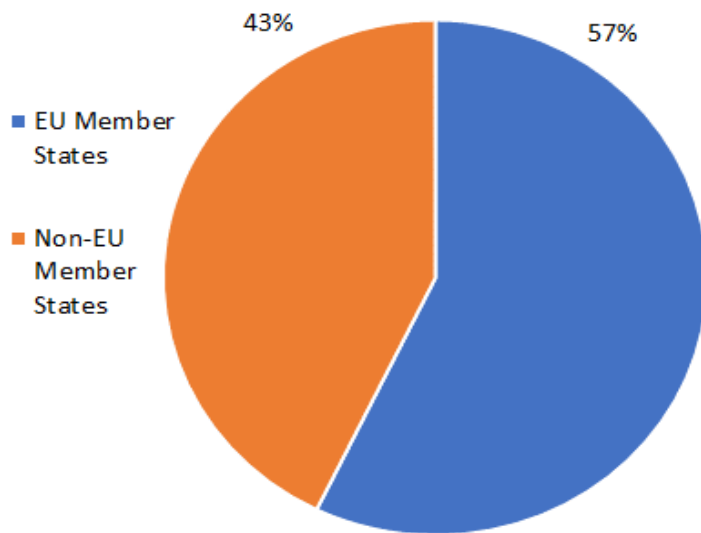
Figure 7: Distribution of food products reported in food fraud cases according to their European origin.

4.6 Most Prevalent Notification Type

The most common type of notification was border rejection, accounting for 65.6% of notifications (1333 out of 2031 cases). This was followed by information notifications, which comprised 29.7% of notifications (603 out of 2031 cases). Alerts were the least frequent type of notification, with only 4.7% (95 out of 2031 cases). The primary reason for border rejection was the border control where the consignment was detained. This reason constituted 98.27% (1310 out of 1333 cases) of border rejections. In contrast, the primary reason for both information and alert notifications was official control within the market. This reason was responsible for 57.55% of information notifications (347 out of 603 cases) and 90.53% of alert notifications (86 out of 95 cases).
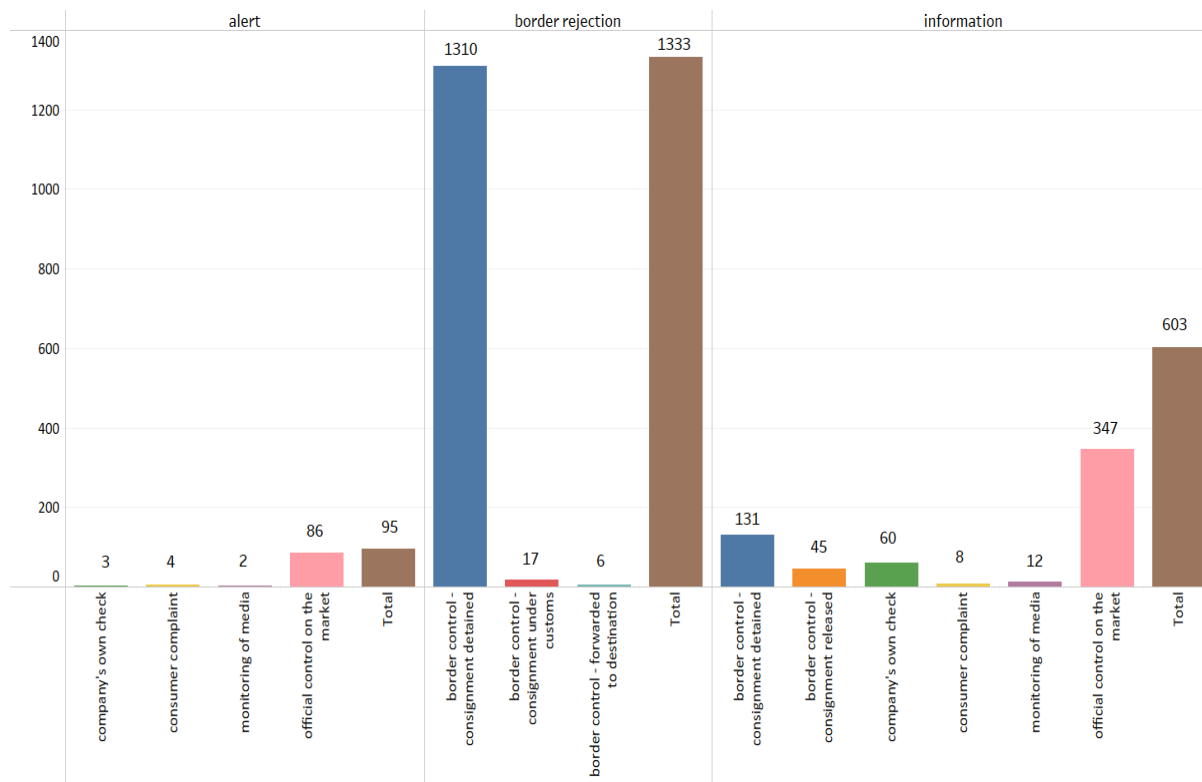
Figure 8: Distribution of the different types of notifications used by reporting authorities.

CHAPTER 5

DISCUSSION

This study reveals the intricate landscape of food fraud within the EU. While food fraud has been present for a long time, accurately gauging the scope of the issue remains challenging because the documented cases could likely represent only a minor portion of its true magnitude (Wisniewski & Buschulte, 2019). As reported in the RASFF, food fraud is widespread across diverse geographical regions, including EU Member States, the United Kingdom, Iceland, Norway, and Switzerland. The RASFF database recorded 2031 food fraud cases during the period, 2005 to 2021. The prevalence of food fraud exhibits notable disparities and varying degrees among countries, which signify different vulnerabilities and enforcement capacities. This indicates that the effort to fight food fraud should have more country-specific approaches instead of a "one-way" approach for all countries. Remarkably, the United Kingdom, a former EU Member State until January 2021, emerged as a focal point with the most reported cases (31.76%). This finding could be inherent in the fact that the United Kingdom is one of the countries that import the most food, as inferred from current statistics (WTO, 2019, 2020, 2021). Yet, they did not have a national food fraud or food crime unit until after the review of the horsemeat scandal, which recommended the establishment of the National Food Crime Unit in 2015 (Food Standards Agency, 2021). Italy (9.01%), Spain (8.07%), Germany (5.81%), and France (5.22%) follow the United Kingdom in terms of reported cases. Thus, collectively contributing to nearly 60% of all food fraud cases documented within the RASFF database. The fact that these countries appear prominently on the list does not necessarily mean that their food business operators or industries are more prone to committing fraud than others. Instead, it could indicate that these countries have robust systems in place for reporting, monitoring, and addressing food fraud. The higher number of reported cases may also indicate that these countries are aware of the prevalence of food fraud in their countries and have become more vigilant, and actively taking steps to identify and tackle the issue. This proactive stance is essential for upholding consumer trust and ensuring food safety.

Additionally, although the prevalence of food fraud cannot be directly interpreted as reflecting the rigidness, intentional or unintentional defiance to EU regulations and the EU food control system, it provides a comprehensive overview of the significance of food fraud

as a pervasive issue requiring careful attention and strategic intervention within the EU. Among the various types of food fraud, the most prevalent is the forgery of documents, accounting for approximately half of all the food fraud cases during the study period with a significant portion of 53.27%. The issue of forgery of documents emphasizes the susceptibility and ease of manipulating documents (Soon, 2022). At the forefront of the forgery of documents is the manipulation of health certificates which involve absent, expired, fraudulent, and improper health certificates. The prevalence of grey market activities, accounting for a substantial 33.68% of reported cases, may indicate the existence of unauthorised distribution, parallel distribution channels, and illicit trade within the already complex EU food supply chain. This finding aligns with the concerns expressed by van Ruth et al. (2017) who explained that as the complexity of a food supply chain increases, the ability to maintain surveillance and control within the supply chain diminishes. This, in turn, enhances the susceptibility to fraudulent activities. Unauthorised or illegal food import was identified as the primary method of grey market activities. Even though most unauthorised or illegally imported foods were controlled at the borders and the consignments were detained, the prevalence of unauthorised or illegal food import illustrates the ever-increasing challenge of traceability in food supply chains. The remaining cases are attributed to adulteration and tampering (9.21%), mislabelling (3.69%), and counterfeiting (0.15%). Thus, emphasizing the diverse strategies employed by food industries and food business operators to deceive consumers. This echoes the multifaceted nature and typology of commercial fraud outlined by Visciano & Schirone (2021).

Food fraud demonstrates an upward trend with fluctuations, with the highest peak occurring in 2013 and 2017. The increasing trend with notable oscillations is observed in the trends of health certificates (absence/improper/fraudulent/improper/suspicious), certified analytical reports (absence/improper), and common health entry documents (absence/improper/fraudulent), illustrating the dynamic nature of fraudulent practices concerning documents. The trends of these methods of food fraud are marked by recurring fluctuations on average every two years, and these methods exhibited a distinctive surge in 2017. The reason for this peak could be the establishment of Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities. This regulation entered into force in the first half of 2017 and must have helped detect most food fraud cases that year. Conversely, fraud encompassing fake labelling,

wrong labelling, and false product documentation exhibits a declining trend with fluctuations on averagely every three years. This trend may indicate the outcome of the effective countermeasures against deceptive labelling practices. While certain cases of improper, expired, or missing documentation might result from administrative errors, it is essential to note that, the authorities classify these cases within the adulteration/fraud category. Such cases are not classified within the categories of labelling absent/incomplete/incorrect or the poor or insufficient controls categories. Consequently, the scope of this study considered all the cases within the fraud/adulterations category without any omissions. The findings further reveal intriguing dynamics, like the transient surge and subsequent decline over the years in fraud related to unauthorised transit and illegal trade. This highlights the potential influence of immediate and resilient measures in responding to fraud cases related to unauthorised transit and illegal trade. Similarly, the sudden peak in paraffin-related food fraud (coating, presence) in 2021 again highlights the evolving nature of fraudulent methodologies and the necessity for vigilant monitoring. Unauthorised placing on the market recorded a moderate decreasing trend with a high number of cases per year. Thus, the decreasing trend signify the potential suppression of unauthorised placing on the market.

The study also reveals a detailed insight into the types of food products most affected and susceptible to food fraud within the EU. It was identified that different food sectors are more vulnerable to food fraud. Notably, nuts, nut products and seeds emerged as the most susceptible food product category, with a significant 22.01% of reported cases. This finding highlights how food fraud is driven by market demand for high-value products consumed globally because of their well-known beneficial health properties, as Campmajó & Núñez (2021) noted. Fruits and vegetables also had a share of 10.49% of the cases, followed closely by meat and meat products (other than poultry) (10.44%, 212 out of 2031 cases) and fish and fish products (9.50%, 193 out of 2031 cases) which were also significantly impacted.

Notable trends were observed across these four food product categories: nuts, nut products and seeds, fish and fish products, meat and meat products, and fruits and vegetables. Nuts, nut products and seeds, fish and fish products and fruits and vegetables showed upward trends, characterised by gradual fluctuations after each consecutive year. In contrast, meat and meat products (other than poultry) exhibit a downward trend. This finding affirms the vulnerabilities and rate of food fraud present within the fresh produce, animal food, and seafood sector, as Marvin et al. (2016) indicated. This finding also highlights the

complexities inherent in ensuring the integrity of the supply of perishable food products since they have a high probability of causing financial loss to food business operators when they are not bought from the market on time. In such instances, some food business operators may commit food fraud to prevent financial loss. Conversely, the analysis revealed that certain food products from the categories had lower susceptibilities to fraud. These food products are food contact materials, ices and desserts, wine, alcoholic beverages, non-alcoholic beverages, natural mineral water, and food additives and flavourings with each accounting for mere fractions of the reported cases (0.05% to 0.34%). This finding may result from the robust regulatory framework and heightened vigilance in these sectors.

The most prominent combinations of food product categories and types of fraud are (i) Forging documents/nuts, nut products and seeds, herbs and spices, fruits and vegetables, and fish and fish products, (ii) Grey market activities/dietetic foods, food supplements and fortified foods, meat and meat products (other than poultry), fruits and vegetables, and fish and fish products, (iii) Adulteration and tampering/meat and meat products (other than poultry) and prepared dishes and snacks, (iv) Mislabelling/meat and meat products (other than poultry), other food product/mixed and fish and fish products and (v) counterfeiting/soups, broths, sauces, and condiments.

The origin of food products reported in food fraud cases was most commonly Asia (44.66%), making Asia the notable continent for food fraudulent activities. Asia was closely followed by Europe (28.75%), Africa (14.67%), North America (5.71%), and South America (5.12%). The remaining notifications originated from Australia and Oceania and unmentioned or unknown countries (1.08%). For Europe's fraction, 57% of food products originated from EU Member States, against 43% from Non-EU Member States. These fractions indicate the negligence by EU based food business operators and food industries in the supply chain to official controls and regulatory procedures. The breakdown of countries of origin revealed that only six countries contributed to half of all the food fraud cases reported in the RASFF (50.66%). China emerged as the most cited, followed closely by India, Turkey, Nigeria, Ghana and the United States.

The findings of this study reveal differences in the identification of food fraud/adulteration within the EU Member States market and in border rejections. In most instances, most frauds are detected in border control, and a border rejection notification is recorded. This control system detected approximately 65% of food fraud cases. Additionally,

official controls on the market played a crucial role by detecting roughly 21% of food fraud cases. These results show the significance of enhancing national control systems to complement the international systems.

CHAPTER 6

RECOMMENDATION AND CONCLUSION

This chapter presents the recommendations and conclusion of the study. The recommendations aim to strengthen the EU's efforts to combat food fraud.

To begin, the EU and its Member States should engage and collaborate with countries, especially those that are major sources of food fraudulent activities, as revealed in this study, such as China, India, and Turkey. Countries make a lot of revenue from export duties when food industries and food business operators from that country ship their food products to an EU Member State. These collaborative efforts should focus on sharing intelligence, harmonising standards, and developing joint initiatives to combat cross-border food fraud incidents. An example of a joint initiative could be the development and establishment of platforms that allow countries that the food industry or food business operator is exporting their foods first to control, test, authorise and document the authenticity and integrity of the food products in the platform before they are shipped to an EU Member State. This proposed recommendation of fostering collaborative efforts among EU regulatory authorities, the EU Member State, and the export country to tackle food fraud is aligned with the World Trade Organisation (WTO) rules. By advocating for cooperative strategies to design tailored prevention strategies to address food fraud, this approach emphasizes a non-discriminatory cooperation and a shared commitment to consumer protection. These efforts would not only bolster consumer safety and interest but also uphold WTO principles by avoiding unjustified trade barriers, promoting transparency, and fostering equal trade practices. Also, sanctions can be agreed upon and established between the EU and export countries. Hence export countries that do not perform their due diligence are obliged to pay a fine when cross-border food fraud is detected.

Moreover, more flexible country-specific approaches to detecting and preventing food fraud should be adopted, given the differences in prevalence, vulnerabilities and enforcement capacities among EU Member States. Regulatory authorities of the EU should collaborate and work closely with individual countries' regulatory authorities to identify each country's unique challenges and develop specific prevention strategies accordingly. These prevention strategies could include sharing effective risk assessment techniques, best practices and support in providing targeted training to address each country's specific types

of food fraud prevalent in each country. Also, a focus should be placed on increasing the capacity for official controls on the market, which have proven effective in detecting a significant proportion of fraud cases within the EU marketplace.

It is essential for continued research and innovation in detecting and preventing food fraud. The power of the digital landscape offers innovative solutions for detecting and preventing food fraud, and the EU and its Member States should invest in research and innovative control mechanisms. Advanced technologies such as blockchain, digital documentation systems, AI-powered data analytics and spectroscopic methods for rapid product verification can be designed to enhance transparency and traceability across the food supply chain and ensure integrity in the food supply chain. Implementing blockchain technology in the food supply chain can provide real-time tracking of products from their origin to the final consumer. Implementing digital documentation systems in the food supply chain can provide a system where documents can be submitted by food industries and food business operators to EU member states for verification even before their products are shipped or placed on the market before border control and official control on the market takes place. AI-powered data analytics can be introduced in platforms like the RASFF and other databases that Member States use in notifying food fraud for periodic automatic analysis to identify patterns and make future predictions. These technologies would make it significantly harder for fraudulent activities to go undetected.

Finally, consumer education is a key component in preventing food fraud. Targeted campaigns and awareness programs should be launched to help consumers identify fraudulent products if possible and understand labelling regulations and the importance of purchasing from reputable sources. Informed consumers will play a vital role in reducing the demand for fraudulent products, and efforts to combat food fraud can be strengthened.

In conclusion, it is crucial to understand why and how food fraud happens in order to prevent it and deter potential financial gain by imposing strong penalties. Many instances of food fraud remain unnoticed and unrecorded; hence, more research is needed to determine novel methods for detecting food fraud, how they impact the extent and nature of it, and the number of consumers affected. If we allow opportunistic behaviour on the part of some food industries and food business operators to persist unchecked or fail to stop their operations and enforce preventive measures, this behaviour could lead to a more widespread, organised and systemic form of fraud.

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