What works to prevent food fraud

Executive Summary: What works to prevent food fraud

Aims

This study was undertaken to guide the FSA and the [National Food Crime Unit (NFCU)](#) on the development of future strategies and operational activities to improve food fraud prevention.

Its aims were to:

(1) Investigate successful initiatives and strategies for fraud prevention and especially food fraud prevention; (2) understand what has worked well in preventing commodity-based fraud (including food fraud) and the lessons learned from these initiatives and strategies; (3) provide recommendations which could be adopted by the NFCU and incorporated into the unit's key strategies; and (4) provide recommendations for any future research required within this area.

The key research questions which underpinned these objectives were: (1) What food fraud prevention strategies and initiatives have been implemented in the UK and other countries? (2) What strategies and initiatives have been implemented to prevent and tackle commodity-based fraud in other industries? (3) What conditions need to be in place to enable fraud prevention strategies to be successful?

Approach

1. A review of academic and policy literature where 151 sources were identified and reviewed that considered prevention initiatives focused on food-related crime, food fraud, and food defence
2. Interviews with domestic and international experts, including representatives from organisations which have established fraud prevention strategies. Sixteen interviews were conducted with interviewees from a range of backgrounds including food businesses, law enforcement, Official Controls, food testing service providers, private and public food governance organisations, and academia.

Findings

At a food business operator (FBO) level, reactive detection dominates especially where financial, knowledge, and time resources are limited. The current regulatory approach towards food fraud of using intelligence, policing perspectives, and laboratory authentication is perceived as focusing more on reactive detection rather than prevention strategies. Addressing the transition from food fraud detection to prevention strategies at FBO level should be a priority.

Globally, for decades, the hazard analysis critical control point (HACCP) approach has been used successfully by businesses as a food safety prevention tool. First generation assessment tools have been developed for food fraud, wider food crime, and food defence such as threat analysis critical control point (TACCP) and vulnerability assessment critical control point (VACCP) and SSAFE's food fraud vulnerability assessment tool (food fraud). The FSA's food fraud resilience self-assessment tool also provides an alternative approach for small and medium-sized enterprises (SMEs). Having three HACCP, VACCP, and TACCP assessments with minimal interoperability is cumbersome for FBOs, particularly SMEs. The adoption of hazard analysis critical control point food defence plans (HACCP-DP) combining hazard and threat analysis into a single assessment would be of value at regulatory and business levels. Hurdle effect strategies (a combination of multiple preventative measures (hurdles) that in combination reduce the likelihood of a food safety or food fraud event occurring) offer promise in food fraud prevention. Extending 'hurdle effect' thinking from food safety assurance and food preservation to food fraud prevention is essential. The development of integrated food control management systems (FCMSs) with FBO level, supply chain level, and state level verification are crucial. Verifying the efficacy of FCMSs as an economic, social, and cultural ecosystem is essential to food fraud prevention.

FBOs can minimise fraud risk by operating effective upstream prevention strategies (from the business back through to all tiers of suppliers). Focused supplier approval and procurement processes where embedded in 'business as usual' are an essential 'what works' strategy. Supply chain pressures and practices to deliver low-margin and lower cost food products can promote mindsets and an operating environment where deception, misrepresentation, and fraud occur. 'What works' in supply chain management practice needs to be disseminated more widely.

SMEs need further guidance and appropriate tools to help them identify vulnerability and mitigate food fraud risk within a FCMS. Food fraud vulnerability assessment guidance within existing tools such as [Safer Food Better Business Guidance](#) would be of value to SMEs.

Vulnerability assessment is only the first stage of developing a food fraud prevention strategy within a FCMS. Second and third generation tools and fraud prevention approaches are being adopted by industry. Investment by large organisations in bespoke early warning systems using a range of intelligence is informing a more effective preventive response. Excellent intelligence sharing networks exist, but, a step-change is needed in embedding food fraud prevention strategies within the NFCU to aspire to deliver frictionless integration of real-time data sharing. Access to the information created within early warning systems, supported by appropriate data governance structures for intelligence sharing between parties would accelerate the abilities of

NFCU to tackle food fraud.

Better organisation of real-time and historic evidence sources to inform food fraud prevention at national level is essential. The NFCU does produce strategic assessments and disseminates information through newsletters. The recent NFCU External Review 2022 has suggested further developments within the NFCU should consider improved communication strategies for disseminating the scale and the specificity of the food fraud threat. Lack of reliable real-time intelligence also makes it difficult for regulators to know where to focus resources to prevent food fraud.

Rural crime prevention is under-resourced. For police officers, food fraud and wider food crime may be encountered seldom in their career and by intention fraudulent activities operate 'in the shadows.' Improved knowledge management practices would better support a preventive strategy and inform and guide police officers when they suspect any illegal activity associated with farming, food, and food supply.

Guardianship strategies and a network of capable guardians would underpin the NFCU adopting and operationalising an effective food fraud prevention strategy. Integrating a guardianship network and intelligence gathering processes would support effective verification of the national FCMS as an economic, social, and cultural ecosystem. An initial phase would map out an agile, integrated guardianship network in the UK food and beverage context, and existing data that could be collated in addition to activities of existing networks.

The social and psychological contexts of food fraud must be better understood from identifying fraudsters, their modes of operation, causation, rationalisation, and motivation to then inform effective food fraud prevention strategies. These strategies need to operate at multiple levels of the food system. Food fraud is often operated in parallel with intentionally illegal business operations that are focused on crime, and often active in multiple illicit activities. Food fraud prevention strategies need to also focus on preventing organised illegal activities activity by perpetrators operating outside of existing networks.

Future FSA research needs to consider how 'what works' can be embedded into accessible guidance for the NFCU and for FBOs. Further research should consider the value of fraud prevention strategies such as forensic accounting and triangulation of intelligence as part of a verification ecosystem, which has been found to be of value in other sectors.

Introduction: What works to prevent food fraud

The aim of our study was to guide the future development of the National Food Crime Unit (NFCU) by providing a greater understanding of their role in prevention strategies to reduce food fraud.

The NFCU defines food crime as 'serious fraud and related criminality within food supply chains,' and identifies seven types of activity which can manifest within food crime offences. Food crimes will often include the application of more than one of these activities within a single pattern of offending.

Theft - dishonestly obtaining food, drink, or feed products to profit from their use or sale.

1. Illegal processing - slaughtering or preparing meat and related products in unapproved premises or using unauthorised techniques.
2. Waste diversion - illegally diverting food, drink or feed meant for disposal, back into the supply chain.

3. Adulteration - including a foreign substance which is not on the product's label to lower costs or fake a higher quality.
4. Substitution - replacing a food or ingredient with another substance that is similar but inferior.
5. Misrepresentation - marketing or labelling a product to wrongly portray its quality, safety, origin, or freshness.
6. Document fraud - making, using, or possessing false documents with the intent to sell or market a fraudulent or substandard product.

According to the FSA and [Department of the Environment, Food and Rural Affairs (Defra)](#), food fraud is defined as the act of "deliberately placing food on the market for financial gain, with the intention of deceiving the consumer" (Defra, 2014). There are multiple definitions of food crime and food fraud. Appendix 2 contains a glossary of food crime and food fraud related terms that are used in this report. Appendix 3 provides background to the definitions and meanings of food fraud assimilated from the literature.

The approach our research took was to:

1. Investigate strategies for the prevention of food fraud which have been successfully utilised in other countries and organisations outside of the FSA (both within the UK and internationally);
2. Understand what has worked well in preventing food fraud and the lessons learned from these initiatives/strategies;
3. Understand what has worked well in preventing fraud in other commodity/ physical goods-based industries (for example, pharmaceuticals) and the lessons learnt from these strategies;
4. Provide recommendations which could be adopted by the NFCU and incorporated into the Unit's key strategies; and
5. Provide recommendations for any future research required within this area.

Methodology: What works to prevent food fraud

Full details of the methodology can be found in Appendix 4. The study conducted a systematic literature review and supplementary interviews with stakeholders to understand 'what works' or 'what may work' in preventing food fraud.

Literature review

The review adopted a comprehensive search strategy considering all available evidence in the public domain, including peer-reviewed articles, grey literature (for example, government and industry reports), and relevant government reports. This included previously published systematic and critical reviews on this subject, as well as primary research. A list of the databases, key search terms, and indicative criteria for inclusion and rejection based on the quality of the studies considered is provided (Appendix 4). The main review questions were:

1. What food fraud prevention strategies and initiatives have been implemented in the UK and other countries?
2. What strategies/initiatives have been implemented to prevent and tackle commodity-based fraud in other industries?

3. What conditions need to be in place to enable fraud prevention strategies to be successful?

In total, 39,132 sources were initially identified but there was a considerable overlap between databases with 20,406 duplicates. A snowballing approach was then followed with additional searches through Google, other references, and through contact with seminal authors. The management of sources, screening, exclusion and then extraction was managed through Covidence an online tool for systematic reviewing. One-hundred and fifty-one (151) sources went forward for full extraction, descriptive analysis, and synthesis.

Supplementary interviews

In parallel to the literature review, a series of sixteen semi-structured interviews with professionals working on food fraud/crime were carried out (Appendix 5). The online interviews, using MS Teams, were recorded, and later transcribed. All interviewees were granted anonymity and their data was stored securely on the University of Lincoln OneDrive. A pilot interview was conducted to sense check and improve the interview schedule.

The purpose of the interviews was to get an in-depth understanding of current approaches to food fraud prevention and what can be done to improve prevention practices across the sector and within the role of the NFCU. The differences between detection and prevention where also discussed at some length. Extracts from the anonymised interviews are used to explain findings in this report (Appendix 6).

All sixteen participants had significant experience and knowledge of fraud and crime prevention and detection. Many of the participants have been working in the food sector for many years and their experience adds valuable insight into current practice, what works and what needs to be improved to tackle food fraud. Some participants worked in senior roles for multi-national companies involved in the food industry and others worked with SME food companies. We also interviewed leading academics, accountants involved in auditing the food sector, individuals working in laboratories testing food, and working for Local Authorities, non-governmental organisations (NGOs), and international organisations such as the World Health Organisation (WHO) and United Nations (UN). The codebook derived from content and thematic analysis of the interviews is included in the report (Appendix 7).

Key findings: What works to prevent food fraud

Introduction

A range of academic literature, government publications, and stakeholders have defined food fraud and offered guidance on prevention and mitigation strategies (Appendix 3). It is clear from the literature that a lack of understanding of fraud and what types of fraud may occur has left the food industry vulnerable (Spink et al., 2019a). Therefore, prevention and mitigation strategies can be generalised and not specific to a particular food product, or supply chain (Appendix 8). Prevention strategies are expensive to implement and their ability to actually prevent a threat, which may or may not occur, is difficult to measure. In addition, the balance between adopting prevention strategies and detection strategies is difficult to position especially whether these sit under the responsibility of the regulator or the industry. Manning and Kowalska (2021) identify some critical challenges in this area such as the need to harmonise food fraud and food crime definitions at the European Union (EU) and international level, the need for convergence of

private and regulatory approaches to food crime and food fraud classification and seeking opportunities to improve the effectiveness and efficiency of systems of verification and of governance systems. This integration is essential to combat food fraud and facilitate consumer trust in food and the integrity of food supply chains.

Multiple types of food fraud have been characterised in the literature (Spink et al., 2016a; 2016b; 2017), as has the advent of the use of threat analysis critical control point (TACCP), vulnerability analysis critical control point (VACCP), food fraud initial screening (FFIS) (Spink et al., 2016a); food fraud vulnerability assessment (FFVA) (Spink et al., 2019; van Ruth et al., 2017; 2020); food fraud prevention plans (FFPPs) (Spink et al., 2019) and the SSAFE food fraud diagnostic tool (van Ruth et al., 2017; 2020). The use of FFVA within food integrity culture assessment tools has very recently been proposed by Alrobaish et al. (2021; 2022a; 2022b; 2023). However, there are challenges for food business operators (FBOs) with regards to having sufficient resources to develop multiple prevention plans and with interoperability between plans especially at the micro and small business level.

Understanding food fraud as being 'enterprise-related' re-organises prevention approaches to better understand situations, contexts, and structures that create pressure, drive, or 'make rational' the decisions by perpetrators to engage in fraud. Whilst guidance such as PAS 96 (BSI, 2017) provides a typology of the food criminal, the characterisation of the food fraudster is less well defined and less well disseminated to FBOs. This is in part due to the wide range of types of fraud and crime that would need to be addressed for a vulnerability assessment to be seen as exhaustive (see Appendix 3). The lack of an internationally accepted definition of food fraud, and more widely food crime, and food defence, is a barrier to defining the food fraudster as well. The fraudster can be characterised in terms of the increasing sophistication of their activities from recreational, occasional, occupational, through to professional, or in terms of their role in the criminal activity (Williams, 2001; Spink et al., 2013; Manning et al., 2016). Whilst macro-level factors frame their activities, fraudsters are motivated by micro-level factors such as their location, business, or activities they are involved in, working and business relationships, specific and shifts in cost drivers, and the level of economic gain that can be derived from acting illegally (Moyer et al., 2017). Setting illegal food operations aside, where the intention from the start of operation is not to comply with the law, Moyer et al. (2017) argue that most food fraudsters are occupational criminals, conducting their activities within FBOs in legitimate food supply chains.

In this sense, we must understand food fraud as 'situated action.' The concept, originally coined by Lucy Suchman (1987), has been notably applied in the related criminological area of organisational crime by Vaughan (1996; 1998; 2007) who states: 'fundamental sociological understanding is that interaction takes place in socially organised settings. Rather than isolating action from its circumstances, the task... is to uncover the relationship between the individual act and the social context' (Vaughan, 1998). We must therefore consider how specific situations, including the material and social circumstances and conditions, shape offending behaviour and how to subsequently intervene with these facilitative situations. By analysing situated actions, theories of situational prevention can be integrated within the framing of food fraud as enterprise crime. Guardianship (where a guardian is a person or an object that is effective in deterring criminal offenses) and hurdles (a combination of multiple preventative measures) are two aspects that are focused on in this report.

In terms of 'what works', situational crime prevention (SCP) theory (focusing on the settings where crime occurs, rather than on those committing specific criminal acts) has been used in the development of food fraud prevention tools to support the exploration of the circumstances of crime and in particular the availability of opportunities to commit crime using the principles of routine activity theory (Cohen and Felson, 1979; Spink et al., 2016; Lord et al., 2017; Spink et al., 2019). Thus, rather than focusing on the causes of crime or inherent criminal motivations and propensities, the theory focuses on practical, situation relevant ways of reducing opportunities for crime or minimising their harms should they occur. Lord et al. (2017) suggest that prevention measures can focus on five specific areas, which we have reframed below in the context of food

supply chains:

1. **Increase the effort** (for example, make it harder to adulterate food products or to hide frauds behind legitimate business practices by increasing transparency. Examples of industry practice include developing supply chain procurement protocols that increase supplier visibility; implementing security practices such as driver controls on company sites; fob or fingerprint entry to high-risk areas of the factory; improving facility design and enclosing areas of the factory or the production line where adulteration could take place).
2. **Increase the risks** (for example, increase routine surveillance of the business environment or 'offending locations', or the likelihood of being detected such as buyers and consumers. Implement security audits on the premises, install CCTV).
3. **Reduce the rewards** (for example, separate products within the business or confiscate profits gained. Increase the penalties associated with food fraud, such as supplier delisting or potential prosecution).
4. **Reduce the temptations** (for example, reduce temptations to commit fraud by ensuring legitimate business is profitable or neutralising organisational/market pressures. Examples include developing long term relationships with suppliers and developing communication channels to discuss external, market, and business pressures).
5. **Remove the excuses** (for example, introduce more prescriptive rules or educate offenders to harms caused. Develop awareness training within the organisation so that the harm associated with food fraud can be effectively communicated).

The Food Safety Act 1990, and associated legislation has led to the adoption of preventive strategies to reduce food safety incidents. EU Regulation (EC) 852/2004 required all FBOs to "put in place, implement and maintain a permanent procedure or procedures based on HACCP (hazard analysis critical control point) principles." The HACCP approach within the internationally agreed General Principles of Food Hygiene (Codex, 2020) has been successfully adopted globally as a food safety prevention tool. In the literature review and the interviews, it was highlighted that food fraud prevention approaches need to be fundamentally different to food safety prevention approaches on the basis that HACCP is designed to address unintentional actions and known knowns and unknown knowns in terms of existing food safety hazards. Alternatively, food fraud arises due to intentional furtive acts, i.e., known unknowns and unknown unknowns so prevention approaches may need to be different.

Whilst it is the government's responsibility to set clear legal requirements for prevention strategies to reduce food fraud, it is also the responsibility of the industry to embed appropriate strategies to prevent, detect, and mitigate food fraud risk(s) (Spink and Moyer, 2011). Thus, the food industry is ultimately responsible for the quality and safety of its products and for food fraud mitigation activities and prevention (Wisniewski and Buschulte, 2019). Prevention and detection strategies aim to control, and where possible eliminate, food fraud. Prevention strategies assume that the root cause of an event can be eliminated or at least significantly reduced to stop a fraudulent activity taking place (Moyer et al., 2017; Spink et al., 2017; 2019a). Mitigation strategies assume food fraud events will occur, and can be detected, and focus on trying to eliminate or reduce the negative consequences that could result (Spink et al., 2017; 2019a).

In the wake of the Elliot Report in 2014, the UK Food and Drink Federation (FDF) produced a guide for food and drink manufacturing businesses to protect their business from food fraud (FDF, 2014). This guide is designed to support businesses to identify, prioritise and manage upstream supply chains (from the business back through to all tiers of suppliers). Upstream thinking has been an emergent theme in our study as an essential prevention strategy for businesses to reduce food fraud and will be explored more in subsequent section. Businesses such as Nestlé also have produced guidance on food fraud prevention (Nestlé, 2016) again with a strong focus on supply chain management through upstream thinking and highlighting the need for vulnerability assessment to inform mitigation strategies as a key preventive process. However, access to such guidance for micro and small businesses is difficult and requires individuals to

have knowledge about food fraud, the means for its prevention and mitigation and how these can be adopted within their business. The FSA Food Fraud Resilience Self-Assessment Tool launched in 2021 (FSA, 2022) has been developed to guide businesses to identify food fraud risk and the steps that can be taken to mitigate that risk.

The term Food Control Management System (FCMS) refers to the overall control of the FBO's processes i.e., encompassing food safety, nature, substance and quality, food authenticity and food integrity, compliance with statutory compositional standards, traceability, food fraud, food defence and management activities including validation, monitoring, and verification. The FCMS constitute the FBO's default means of preventing food fraud. Effective multiple verification of the FCMS is logically a significant enabler of preventing food fraud. Verification is most frequently implemented through auditing which has been perceived as a crucial component in ensuring compliance with regulatory and market standards and maintaining third party certification. Auditing is also perceived as a means to assure traceability systems are effective and provide transparency that FCMS are adopted, implemented, and effective. Audits rely upon as independent, objective assessments of an FBO's FCMS, including the level of adherence within the day-to-day operations and assessment of the FBO's food safety culture (how everyone (owners, managers, employees) thinks and acts in their daily job to make sure the food they make, serve, or retail is safe). This has been extended to include food integrity culture in recent research (Alrobaish et al., 2021; 2022a; 2022b; 2023).

Types of FBO verification includes internal FBO verification (1st party), supplier-customer (2nd party) and 3rd party private standards certification (for example, BRC/ISO22000) and Official Controls, i.e., statutory State delivered verification, primarily delivered in the UK by border controls, local authorities, and the FSA. Notwithstanding the effort and considerable expense that has gone into auditing to date, existing public and private auditing processes alone are not sufficient in themselves to prevent fraud. Instead, audits need to be part of a triangulation of verification or a wider verification ecosystem. For example, auditing activities failed to prevent the horsemeat or ethylene oxide incidents in Europe. Earlier work at State and Federal level in the US tended to show an inconclusive relationship between inspections and audits and the prevention of foodborne illness outbreaks (Irwin et al., 1989; Cruz et al., 2001; Petran et al., 2012). Furthermore, inspection and audits alone may be too infrequent to verify vulnerabilities effectively (Kaplan, 1978) and illicit behaviour is unlikely during an inspection or audit. Concerns over the practice of auditing and fraud prevention are not confined to the food sector with a range of concerns emergent in the banking sector, for example. Auditing is confounded by conspiracies (Dai and Handley-Schachier, 2015), or auditors may be looking primarily for compliance and not consider detecting and reporting fraud as being within their remit (Chong, 2013), or contractual arrangements between auditors and auditee organisation prohibit or mediate the open disclosure of fraudulent activities (Mansor et al., 2020). This was a point highlighted in the interviews with regard to third party certification in the food supply chain.

The following sections combine the findings from our literature review, further iterative evidence reviews, exploration of industry and policy evidence, and the interviews. The evidence has been triangulated (compared) based on the level of agreement found between academic, industry, and policy sources, and the interviews. This report has sought to highlight the key findings on 'what works' from a limited evidence base and in what is a very complex and intricate subject. Where particular concepts are considered in the findings and the study team consider that further background information is required, this is included in the Appendices.

We have summarised 'what works' in terms of food fraud prevention strategies from different countries, in the food industry and different sectors. Due to the complex nature of the contributory factors that can lead to food fraud, there is no single silver bullet solution and no sole guardian who can eliminate fraud or deliver effective food fraud prevention strategies. The examples provided here are not designed to be exhaustive. They do demonstrate that for effective food fraud prevention to occur there is a need for a high level of interoperability between public and

private (industry) food fraud prevention approaches, what is described in the report as a verification ecosystem.

Food fraud prevention strategies and initiatives implemented in the UK and other countries

In this section, regulatory response in developing food fraud prevention strategies at an international level are first considered, followed by those at the state level and then the industry response. These examples are not exhaustive and are presented to demonstrate the strategies being considered.
United Nations Guidelines for Consumer Protection

Globally, domestic legal strategies for countering food fraud may rely on the guidance provided by the United Nations Guidelines for Consumer Protection (UNGCP, 2016), which established a set of international consumer law principles (Benöhr, 2020). For a domestic national regulator, two general principles can be delineated from the UNGCP framework, that are applicable to developing national food fraud prevention plans (FFPPs):

- **Facilitating best practice by food businesses.** Governments should encourage food businesses to adopt best or good practices by providing criteria and guidance on how to avoid food fraud to protect consumers. Whilst these best practices may initially be voluntary, once implemented and proven to be successful, they could be considered for policy formation/revision.
- **Empowering enforcement agencies to investigate and share information**. Governments should empower enforcement agencies to investigate fraud by coordinating the investigations and enforcement activities with the enforcement agencies of the other UN Member States (Guideline 83), by making use of existing international networks and entering into appropriate bilateral and multilateral arrangements and other initiatives to implement these guidelines (Guideline 85). The UNGCP also calls for the UN Member States to provide their consumer protection enforcement agencies with the authority to investigate, pursue, obtain, and where appropriate, share relevant information and evidence with other enforcement agencies (Guideline 88).
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United States (US) National Security Memorandum on Strengthening the Security and Resilience of US Food and Agriculture

Recently (November 10, 2022) the US government published a National Security Memorandum on Strengthening the Security and Resilience of US Food and Agriculture (US, 2022) as a critical national infrastructure. The Memorandum requires the determination of relevant risks and the completion of vulnerability assessments for the food and agriculture sector at Secretary of State and Agency level. These assessments need to be reviewed when there are emergent, credible, and actionable threats or events, including the need for alternative production or processing steps in food supply chains. Comprehensive regulatory risk assessment (encompassing threat and vulnerability assessment), prioritisation of the risks of most significance, the development of a strategy and action plan, identification of capabilities and a cost/benefit plan will then be submitted to the President.

US Food Safety Modernisation Act (FSMA) Final Rule on Foreign Supplier Verification Programmes (FSVP) for Importers of Food for Humans and Animals
The US FSMA Final Rule on Foreign Supplier Verification Programmes (FSVP) for Importers of Food for Humans and Animals (FDA, 2016) requires FBO importers to perform risk-based foreign supplier verification activities to verify that:

The food is produced in a manner that provides the same level of public health protection as section 418 (concerning hazard analysis and risk-based preventive controls) or 419 (concerning standards for the safe production and harvesting of certain fruits and vegetables that are raw agricultural commodities of the Federal Food Drug and Cosmetic Act or FDandC Act (21 U.S.C 350g and 350h), if applicable.

- The food is not adulterated under section 402 of the FDandC Act (21 U.S.C 342); and
- The human food is not misbranded under section 403(w) of the FDandC Act (21 U.S.C. 343(w)) (concerning food allergen labelling).

Whilst FSVP is primarily focused on food safety, it also addresses aspects of food fraud such as adulteration and misbranding. Supplier verification, undertaken by FBOs is what the Elliot Review (2014) described as upstream prevention, and is a key aspect of a national food fraud prevention strategy (FFPS) that informs a national FFPP. This theme is developed later in this report.

In the Australian context, a regulatory pluralism framework is proposed coupling existing regulatory controls, non-destructive sampling, and innovative technology to enhance and strengthen Australia's regulatory response to fraud (Lindley et al., 2012). Regulatory pluralism is also a theme explored in the next example.

Joint Nordic Threat Assessment for Food Fraud

The Joint Nordic Threat Assessment for Food Fraud was initiated after the 2013 horsemeat incident in Europe (Nordic Council of Ministers, 2022). The NFCU were contributors to the assessment approach developed. In early 2018, joint threats from criminal activity in the Nordic food production chain was considered by four countries: Norway, Denmark, Iceland, and Sweden. In 2019, Norway, Sweden and Denmark carried out national level threat assessments with the priority areas: raw materials of animal origin (tax and customs evasion, smuggling, theft, substitution, and unlawful production and processes); fish and seafood; declaration of Nordic origin, and declaration of organic production. The threat assessment considered opportunities, motivation, supervisory measures, and impact using a risk matrix approach. The use of a risk matrix approach mirrors the approach of the SSAFE food fraud vulnerability assessments, albeit that the individual steps undertaken in the assessment process vary slightly (see Appendix 8 for a more detailed cross comparison). Interestingly, the Joint Nordic Threat Assessment for Food Fraud used a scoring process of high, moderate, low, and unknown, recognising that there are knowledge gaps in the understanding of food fraud (and food defence) threats, which is different to other threat and vulnerability assessments (Appendix 8) as the unknown category was not found in any other of the vulnerability assessments or threat assessments highlighted in this study. Two financial parameters were also assessed, reputational loss and financial loss, and two social parameters: food safety and consumer confidence.

The following aspects of supply chain level and FBO level FFPPs and the countermeasures that could be adopted to reduce national vulnerability were considered:

- Defining and operationalising high moral and ethical standards,
- Screening of potential employees,
- Supportive whistleblowing schemes,
- Auditing of suppliers and supplier requirements,
- Social supervision and transparency in the supply chain/value chain, and
- Knowledge development through guidance/advice for the prevention of fraud in the supply chain/value chain.

At regulator level the following were considered:

- Specific national policies to combat food crime, and

- Government initiatives and enforcement of legislation.

The report is clear that the focus should be on threat assessment rather than risk assessment. We would echo that sentiment.

Exemplar quotes from the interviews that align with the need for this strategic development and capability building within the FSA, Defra, and the NFCU are presented in Appendix 6. Increasing public awareness, inter-agency cooperation, strict enforcement of fraud regulations, and establishing a surveillance and fraud alert system are all essential at regulator level for effective fraud prevention (Braden, 2014).

The UK Legislative and Official Controls Context for Food Fraud Prevention

Prior to 1995, UK Food Safety law tended to address mainly infrastructure requirements of food premises. As identified in several seminal works (Bryan, 1978; Bryan, 1988; Bryan, 1992; Roberts, 1982; Gould et al., 2013), such basic hygiene and sanitary requirements were found to have little bearing on the actual causes of foodborne illness, as they do not capture system level failures. This position has parallels with the prevention of food fraud. The position on food safety changed with the advent of Regulation (4) 3 of the Food Safety (General Food Hygiene) Regulations 1995 which codified for the first time into UK law requirements for HACCP, a preventative approach, requiring FBOs to identify, control and manage the food hazards associated with their business. (The HACCP requirements were re-stated and extended in 2006 by Regulation (EC)852/2004). Combined with the Food Safety Act 1990 this provides a statutory driver for Local Authorities to engage with inspections what became known as Official Controls placing great emphasis on Regulation 4 (3) i.e., verifying the measures for the prevention of foodborne illness. This was augmented by guidance and education programmes aimed at FBOs and delivered by Local Authorities. In retrospect the requirement for HACCP to support prevention of food safety incidents, and the associated guidance and education programmes has been highly transformative for the sector. The Food Law Code of Practice compliance data verifies the success of this programme. There has never been in UK Food Law an analogue for food fraud in addition to the HACCP requirements, i.e., there is nothing that requires an FBO to proactively identify, control, and manage their vulnerabilities to food fraud and consequently there is nothing for Official Controls to enforce, no incentives and sanctions to drive a similar preventive strategy at FBO level.

In response to this context and following recurring criticisms of UK Official Controls from the EU Veterinary Mission, Food Standards Scotland (FSS) in partnership with the Scottish Food Enforcement Liaison Committee (SFELC) embarked upon research into the methods and techniques of auditing. In summary the findings showed there was a tendency to:

1. Verify compliance with the FCMS as written down which frequently related to the requirements of an external standard potentially not appropriate (contextually apposite) or bespoke to the FBO. There was little evidence of challenging the appropriateness and effectiveness of the FCMS in the first place (validation) and related to this was a lack of verification of the suitability of the FCMS to the specific operating circumstances of the FBO , with HACCP plans and FFVAs frequently being generic.
2. Following paper-trails and single sources of evidence increases the risk of being 'fooled' by fraudulent paperwork and other purported 'evidence'.

Related to this is a tendency of inspectors and auditors to rely upon the completion of pre-prepared forms which had not been validated in light of the specific operating contexts of the FBO . The lack of triangulation (comparison with other sources) of objective evidence means that there is the potential for food safety and food fraud risk to exist, even proliferate.

Considering 'what works,' in response SFELC developed Official Control Verification (OCV) which has been accepted by the Scottish Government (SFELC, 2019). OCV is a radical departure from

conventional auditing. A crucial difference is the core principle of OCV being to challenge and verify every aspect of a FCMS, placing particular emphasis on its effectiveness and appropriateness in the first place and to explicitly apply scientific methodology to its verification. This approach uses both validation and verification steps. The FCMS's implementation is also challenged by cross referencing multiple corroborating sources of objective evidence (triangulation). This evidence needs to provide a rigorous evidence base that the FCMS is both appropriate and effective. The range of verification activities and the diversity of evidence assessed (food safety documentation, process documentation, financial documents, etc.) is what is referred to in this report as a verification of an economic, social, and cultural ecosystem. OCV underwent a process of validation within FSS including its science team and then further evaluation with stakeholders including the Scottish Government, the food manufacturing sector and within Official Controls (Improve International, 2018). It was piloted by several Scottish LAs. OCV has been developed further as guidance by the SEAFISH Industry Authority in partnership with the Royal Environmental Health Institute of Scotland (REHIS) and an accredited training course aimed at the verification of food authenticity and integrity including fraud.

The following case study provides an example of the use of collaboration in practice in addressing a food fraud incident.

Operation Tacana – an operational case study

Operation Tacana successfully tackled a major food fraud incident associated with the illegal fishing and export of large quantities of Razor clams (a common burrowing bivalve mollusc found in sandy intertidal and subtidal areas of the Inner Hebrides that have a street-value in Hong Kong and China greater than class A drugs). The illegality in this case had three dimensions: fishing outside waters classified by FSS for food safety, and in relation to ecological based laws requiring sustainable methods of fishing, and falsification of Shellfish Registration documents attesting the safe 'locus of capture' such that the shellfish may legally enter the human food supply chain, i.e., through an establishment approved under Regulation (EC) 852/2004.

Lessons learned that were critical to the success of the operation were the use of systems level innovative thinking, agility in taking action, the use of multi-agency collaboration coordinating their combined powers, and the passage in real time of meaningful 'locus of capture' intelligence from Marine Scotland to the EH Departments. This meant that fishing boats could be boarded and lorries searched at Oban, and there was education of Sheriffs and local politicians regarding the gravity of the issues. Policing perspectives were eschewed in favour of contextually specific knowledge of the food sector and agile action with standardised police digital intelligence reporting systems being bypassed for being cumbersome and delaying the transfer of critical intelligence in critical real time.

First generation food fraud vulnerability assessment and prevention tools in the food industry

Global Food Safety Initiative

Following the horsemeat incident, the Global Food Safety Initiative (GFSI) issued a position document in July 2014 on Mitigating the Public Health Risk of Food Fraud (GFSI, 2014). The document stated two approaches should be followed to mitigate food fraud. Firstly, the guidance recommended businesses should carry out a FFVA which involves gathering information at various points in the supply chain and then undertaking an evaluation to identify and prioritise significant food fraud vulnerabilities. Secondly, the document suggested the determination and implementation of appropriate control measures that are identified in a documented control plan (see Appendix 8). One example of the approaches used is the SSAFE tool promoted by the GFSI

(GFSI, 2019) as a preventive measure. However, this tool requires a pre-requisite level of knowledge and the capability within the FBO to determine its actual vulnerability to fraud. Also, the illicit activities determined as food fraud by the GFSI (2019) do not align with the scope of activities as described by the NFCU. Sector initiatives have driven the adoption of FFVA at FBO level as a pre-condition to supply. Where FBOs are required for market access into retail and food service supply chains to comply with GFSI benchmarked standards there is a clear requirement to complete a FFVA and develop a food fraud prevention strategy. This is not the case for the majority of MSMEs operating outside these retail and food service supply chains and there is little guidance to support their development of food fraud prevention plans via FFVA and associated FCMS.

The lack of guidance for MSMEs especially with regards to criminal theory means that individuals developing FFVA find it difficult in their analysis to 'think like a criminal.' In the interviews the development of FFPS and FFVA was discussed, and the responses were analysed using the construct of the fraud diamond. The elements of the fraud diamond: incentive, opportunity, rationalisation, and capability (see Wolfe and Hermanson, 2004), and other terms used in the Nordic study were used to consider the interview narratives. Other terms emerged from the interviews when 'thinking like a criminal' in developing preventive strategies and FFPPs. These were: consequences (especially a perceived lack of consequences); deterrence (ease of committing fraud); incentive (influenced by competition and economic gain); intention; motivation; opportunities; pressure (power/powerless and social pressure); and rationalisation (see Appendix 6 with exemplar quotes and Appendix 7). These findings align with some of the work proposed by Spink et al. (2019) when considering food fraud prevention strategies.

One option for SMEs is to develop hazard analysis critical control point food defence plans (HACCP-DP) so food safety hazards and food fraud and food defence threats are drawn together in the same document (Wis?niewska, 2015; Manning, 2019). This approach uses the established seven principles and twelve steps of HACCP as building blocks with three further steps to build the food defence element:

Step 1 – determine critical defence points (CDPs) in the process.
Step 2 – define food defence mitigation and control systems including countermeasures.
Step 3 – implement test, assess, and maintain defence mitigation activities (Wis?niewska, 2015; Manning, 2019).
Further research could pilot such approaches with SMEs to develop guidance for FBOs and regulators.

Chain of custody, mass balance analysis, and guardianship

The chain of custody (CoC) system is: "the list of all organisations (supply chain) that take ownership or control of a product during production, processing, shipping and retail (physically and/or administratively)" (ISEAL Alliance, 2016). The CoC system can either be prescribed by regulation, market standards, or developed as part of a supplier assurance programme by an individual organisation. A CoC system can be a key element of a FFPS underpinning the FFPPs at FBO or supply chain level. Appendix 9 Box 1 includes the elements of a CoC system.

Independent mass balance analysis is already a pre-requisite utilised during the verification processes in multiple food supply third party certification schemes such as organic food certification, and the British Retail Consortium (BRC) Global Standard. Mass balance analysis, especially digital real-time mass balance analysis increases transparency through transaction data including the types and quantities of products sourced, from where and for what purpose. Public or state verification of such data would give insights into potential anomalies in the CoC for a food product. Regulators and FBOs can increase the level of deterrence by increasing the effort required by perpetrators to commit food fraud, introducing additional requirements for supply chain transparency, for example, adoption of mass balance analysis using financial and

production data. One example is the Innovate funded The [Digital Sandwich project](#) that uses blockchain-based technology.

Guardians, and in particular guardianship, is a crucial component of deterrence. Guardians monitor and protect food, consumers, FBOs, supply chains, and nations against illegal activity (Cohen and Felson, 1979). Guardianship requires collaboration of multiple actors to create an inter-organisational guardianship network with regulators and enforcement bodies have a specific role in the overarching regulatory protection applied where FBOs are unable to protect themselves or have insufficient information or empowerment to make decisions on their own behalf (Kowalska and Manning, 2022). Effective guardianship (regulations, enforcement, and surveillance systems) by regulators, FBOs and food supply chains can prevent food fraud (Qian et al., 2020; Kowalska and Manning, 2022). In our opinion improving guardianship networks is essential to improving food fraud prevention.

Capable guardianship has been considered in Australia with regard to financial fraud (Lindley et al., 2012) and is a key requirement within national, supply chain level, and FBO level FFPPs in Australia. Within the banking sector and with computer systems technology the guardianship role has been a key focus, as part of a wider verification ecosystem, for example, two step verification of identity when using banking phone apps or logging into computer systems. Ellis et al. (2016) argue that "future sensor/detection platforms and technologies, along with future predictive computational methods could together take on the capable guardian role and assist in significantly reducing the areas of vulnerability to fraud within food supply chains." We would echo that statement.

The next section considers strategies and initiatives have been implemented to prevent and tackle commodity-based fraud in other industries.

Fraud prevention initiatives and strategies from other sectors

We identified publications from other sectors including finance, pharmaceuticals, automobile, technology, and waste management sectors which use systems and processes relevant to the NFCU's work. Publication summarised in this section also focused on workplace fraud and frauds in goods and services chains in general. The following were highlighted as 'what works' or 'may work' in fraud prevention, although comprehensive objective evidence of effectiveness is to date lacking.

Finance sector

- **Good governance practices**. Dianita (2021) suggest the implementation of good governance practices/system coupled with effective monitoring of all operational activities embeds fraud prevention.
- **Standards and guidance documents**. Availability of clear guidance standards focused on approach, mitigation and responsibility must include strategies that are not based on detection alone (DeZoort and Harrison, 2018).
- **Information sharing** is essential to prevent fraud (Burke et al., 2022).
- **Education.** Repeated exposure to guidance on fraud and fraudulent activities (Burke et al., 2022); and workplace-based ethics training (Suh and Shim, 2020) needs to be adopted. The responsibility to raise concerns or whistle blow needs to be reinforced, although this may be difficult in toxic or corrupt environments (Suh and Shim, 2020)

Pharmaceutical sector

The development of FFPPs at multiple levels is reliant on existing systems within FBOs and wider food supply chains such as traceability, transparency, and product integrity. Sources of evidence

in our review that focused on preventing drug counterfeiting in the pharmaceutical sector indicate that digital solutions using different technologies and techniques are being adopted in this sector to reduce the potential for counterfeit and falsified drugs as well as to ensure more transparency, traceability, and efficiency in the pharmaceutical supply chain. In terms of 'what works' internationally recognised pharmacovigilance guidance and standards, the International Council for Harmonisation Guideline E2E on Pharmacovigilance Planning (ICH, 2004) is being adopted for medicinal products to deliver robustness, transparency, and public health (EC, 2019). Pharmacovigilance is 'the science and activities relating to the detection, assessment, understanding and prevention of adverse effects or any other medicine/vaccine related problem' (WHO, 2023). EC Directive 2001/83/EC requires inter-Member State pharmacovigilance systems where each Member State is required to establish a pharmacovigilance system to collect information for surveillance and evaluation of medicinal products of particular interest in terms of preventing dietary supplement fraud (Manning et al., 2022). We recommend that this is an example worthy of further investigation to explore how such systems are implemented and opportunities for learning in terms of food fraud prevention.

Other effective strategies noted were:

- **Multi-level interventions**. Market surveillance, supply chain monitoring, and effective collaboration among all the stakeholders with tracking and measuring performance of interventions to gauge effectiveness is essential (Fadlallah et al., 2017). Unannounced audits are an intervention of value (Zhang et al., 2019). Increasing public awareness, stakeholder cooperation, strict enforcement of fraud regulations, surveillance and establishment of a fraud alert system should be integrated into an intervention system (Deisingh, 2005). There is a need for a combination of both counter and preventive measures such as strong internal control system, periodic auditing, and strong organisation structure for fraud prevention to work effectively (Jalil, 2018; Afiah et al., 2019; Anindya and Adhariani, 2019; Andreatta and Favarin, 2020) and the application of a multi-system approach of e-procurement, whistleblowing, and strong internal control (Primastiwi et al., 2021). However, there is no one-fits all approach in fraud prevention.
- **Traceability, transparency, and information sharing.** International and national cooperation, reporting structures and consistent sharing of information is essential to increase transparency (Cockburn et al., 2005). Use of barcoding systems on primary packaging for vaccines has been [recommended by UNICEF](#) to address counterfeiting Implementing e-systems for full traceability to the individual, allows validation and authentication of all vaccine uses in programmes with the associated safety benefits would prevent fraud (Jarrett et al., 2020). Blockchain enabled Internet of Things (IoT) solutions for smart pharmaceutical traceability systems have also been proposed (Margret et al., 2021).

- **Awareness creation and education.** El-Dahiyat et al. (2021) propose awareness creation and education campaigns about the negative consequences of fraud with all actors. In other sectors social campaigns on fraud were highlighted as a prevention measure (Kowalski, 2018). Senior management should create awareness and understanding of an anti-corruption culture in all elements of the organisation (Jalil, 2018).

Other sectors

- **Elimination of fraud enablers.** DuHadway et al. (2022) suggest that there is a need to build supply chain integrity and transparency to identify and eliminate weak points and gaps within the supply chain that can serve as fraud enablers. One option is to integrate technologies such as blockchain and smart contract so fraud can be more effectively prevented (Chen et al., 2022). The use of data mining and machine learning technologies to monitor the movement of products along the supply chain can aid tracking and monitoring of any unauthorised itinerary and its movements (Camossi et al., 2012).

- **Coordinating effort.** Farrand et al. (2019) highlight the need for transnational support, effective cooperation among the stakeholders, and strict enforcement of extant laws for effective fraud prevention.
- **Embedding a situational crime prevention framework** for designing and testing interventions can be effective for preventing food fraud especially through enhancing rule setting, reducing anonymity, extending guardianship and formal surveillance, and facilitating compliance (Prenzler, 2020).

The next section considers the third research question: what conditions need to be in place to enable successful fraud prevention strategies?

Conclusion: What works to prevent food fraud

This project highlights transferable lessons from food and non-food fraud prevention initiatives that can be incorporated into the NFCU's key strategies.
Overall, there should be further emphasis on prevention, with coordination between government agencies, FBOs, and other key stakeholders to ensure an integrated approach. This collective approach is needed to identify all stakeholders in the food supply chain, increase their awareness and competence regarding food fraud prevention, exclude those FBOs failing to meet applicable standards, and in high-risk food products track food in real time.

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Appendix 2: What works to prevent food fraud- glossary and abbreviations

Term or Acronym	Definition and Clarification
Adulteration	Intentionally adding extraneous, improper, or inferior ingredients to a food product.
Capable Guardians	A capable guardian has a 'human element', that is usually a person who, by their mere presence, would deter potential offenders from perpetrating a food fraud. Examples of capable guardians in food fraud are, Co-Workers, Technical Managers and Environmental Health Officers. Capable Guardianship develops the concept of Guardianship (QV) requiring that they are effective. For example, a capable guardian could also be CCTV, providing that someone is always monitoring the camera, which would otherwise be ineffective. See also Guardianship.
Central Competent Authority	Agencies established by Law responsible for the Policy and Strategy of Food Safety, Food Standards and Food Crime. The Food Standards Agency (FSA) acts for England, Northern Ireland and Wales and Food Standards Scotland (FSS) acts for Scotland.
Countermeasures	The action taken by an individual, organisation, or other body to counteract or offset a given danger or threat.
Due Diligence	Legal defences in response to prosecution proceedings pursuing sections 8, 14 and 15 of the Food Safety Act 1990 intended to provide some mitigation to the strict liability nature of these sections of the Act. Case Law has established that the defence requires setting up a preventative system and ensuring that the system is fully validated, verified, and implemented.
Economically motivated adulteration (EMA)	Economically motivated adulteration is a subset of food fraud. It is the intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production, for economic gain.
Environmental Health Departments (EH Depts)	Departments with Local Authorities (Councils) required by Food Law to deliver Official Controls including the inspection of food businesses and the enforcement of Food Law. Local Authorities are appointed as Local Competent Authorities for Food Law and as Statutory Food Authorities.
Environmental Health Officers (EHOs)	Professionals recognised by retained EU Food law and authorised by UK Food Laws responsible for Public Health including Food Law. EHOs are mainly employed by Local Authorities but are also employed by the FSA and FSS.
Evidence Triangulation	The gathering of objective evidence from three (or more) sources with the purpose of seeking corroboration of these sources of evidence and thereby increasing the certainty of the inference reached. See also Official Control Verification (OCV).
FFVA	See Food Fraud Vulnerability Assessment
Food Authenticity	Food authenticity is the quality of a food to be genuine and undisputed in its nature, origin, identity, and claims, and to meet expected properties.
Food Business Operators (FBOs)	The natural person or legal person (i.e., Company) made responsible by retained EU Food Law for compliance with Food Law.

Term or Acronym	Definition and Clarification
Food Control Management Systems (FCMS)	A modern and emergent concept for a comprehensive food management system covering the following elements – Food Hygiene, Food Safety, Nature, Substance and Quality, Food Standards Labelling and Composition, Food Fraud, Food Crime, Food Defence and Traceability. For example, HACCP, TACCP and VACCP would fall within the scope of the FCMS.
Food Crime	Serious fraud and related criminality within food supply chains.
Food Defence	The process to ensure the security of food and drink and their supply chains from all forms of intentional malicious attack including ideologically motivated attack leading to contamination or supply failure. Thus, food defence strategies can be developed at the national, regional, supply chain, and organisational level.
Food Fraud	Any deliberate action of businesses or individuals to deceive others in regard to the integrity of food to gain undue advantage. Types of food fraud include but not limited to adulteration, substitution, dilution, tampering, simulation, counterfeiting, and misrepresentation.
Food Integrity	The status of a food product where it is authentic and not altered or modified with respect to expected characteristics including, safety, quality, and nutrition.
Food fraud vulnerability assessment (FFVA)	An evaluation of the susceptibility of a system to food fraud. Common features identification, quantification, and prioritisation (or ranking) the vulnerabilities in a system. These assessments have led to the identification of processing steps of highest concern and potential mitigation strategies that may reduce these vulnerabilities
Global Food Safety Initiative (GFSI)	The Global Food Safety Initiative is a private sector business-driven initiative for the continuous improvement of Food Safety management systems with the ambition to ensure confidence in the delivery of safe food to consumers worldwide.
Guardian	A person or an object that is effective in deterring criminal offences and sometimes crime is stopped by simple presence of guardianship in space and time. A guardian would not necessarily have to be a policeman or a security guard but rather a person whose proximity or presence would lower the chances of a crime happening. This could include a consumers, a doorman, a neighbour or a co-worker. Whilst inadvertent, the presence of a guardian has a powerful impact on the likelihood of a food fraud taking place. Thus, when the guardian is not within the vicinity of the target, the likelihood of a crime occurring is significantly higher.
Hazard	A biological, chemical, or physical agent in food with the potential to cause an adverse health effect.
Hazard Analysis Critical Control Point (HACCP)	A system that identifies and enhances control of significant hazards (QV), where necessary. The intent of the HACCP system which is science based is to focus control at Critical Control Points (CCPs). By specifying critical limits for control measures at CCPs and corrective actions when limits are not met, and by producing records that are reviewed before product release.
Horizon Scanning	A systematic process focusing on detecting the early signs of any potential developments relevant to food fraud. An example would be a Typhoon Hagibis which had the potential to disrupt Wasabi supplies and incentivise fraudulent imitation of this valuable commodity.
Intelligence	Information compiled, analysed, and/or disseminated in an effort to anticipate, prevent, or monitor criminal activity.
Mass Balance Analysis	A method and technique of verification (QV). A mass balance is an accounting for all the materials in a process. Mass balance is a detailed and systematic consideration of all the inputs, outputs, and distribution of substances (for example, ingredients, additives packaging, waste) in a food process. Reconciliation is sought between inputs and outputs. Significant differences between inputs and outputs and with the standard operating procedures of the FCMS (QV) can be indicative of further verification and potentially of food fraud.
MOOCS	Massive Open Online Courses.
Official Control Verification (OCV)	A scientific, systematic, and structured approach to verifying FCMSs (QV) based upon the scientific method and explicitly applying deduction and induction through a dual process of Triangulation. OCV was designed to improve the verification of FCMSs (QV), including in relation to food frauds.
Official Controls (OCs)	Official controls are carried out by the competent authorities in the EU countries and the UK to verify FBO (QV) compliance with the requirements set out in agri-food chain legislation. OCs are mainly carried by the Environmental Health Depts of Local Authorities.
Provenance	Refers to the geographic location of where the ingredients and the final food are grown, processed, and finally manufactured and also to how that food is produced and whether the methods of production and processes employed comply with certain standards and protocols.
Quality Assurance Critical Control Points (QUACCP)	An approach to assuring the nature substance, quality, authenticity, and integrity of food derived from HACCP (QV). QUACCP tends to address the prevention of errors rather than deliberate acts such as food fraud.
Routine Activity Theory	One of the main theories of "environmental criminology". The theory states that a crime such as a fraud occurs when the following three elements come together in any given space and time: 1. an accessible target 2. the absence of capable guardians that could intervene 3. the presence of a motivated offender (Cohen and Felson, 1979).
SSAFE	SSAFE is a non-profit membership organization that works through public private partnerships to strengthen the safe supply and trade.

Term or Acronym	Definition and Clarification
Threat	Something that can cause loss or harm, which arises from the ill?intent of people. See also Vulnerabilities.
Threat Assessment Critical Control Point:- (TACCP)	Systematic management of risk through the evaluation of threats, identification of vulnerabilities (QV), and implementation of controls to materials and products, purchasing, processes, premises, distribution networks and business systems by a knowledgeable and trusted team with the authority to implement changes to procedures.
Traceability	The ability to discern, identify and follow the movement of a food or substance intended to be or expected to be incorporated into a food, through all stages of production, processing and distribution.
Triangulation	The cross referencing of three (or more) sources of evidence, propositions, perspectives, or methods in order to seek corroboration the purpose of which is to enhance the certainty of any inferences reached.
US Food Safety Modernisation ACT (FSMA)	An Act passed by then US President Obama with the purpose of transforming the nation's food safety system by shifting the focus from responding to foodborne illness to preventing it.
Verification	The application of methods, procedures, tests and other evaluations, in addition to monitoring, to determine whether a FCMS (QV) is or has been operating as intended. This would include Inspections, Audits, and Sampling carried out by Local Authorities, FBOs and Third-Party Auditing companies. See also Official Control Verification.
Verification ecosystem	The network of interlocking methods and techniques for verification (QV) of food control management systems (QV) in relation to food fraud, encompassing FBO (QV) and state actors.
Vulnerabilities	The weak points or gaps in the formal management systems, or on the manufacturing site itself, that can be identified by perpetrators where their intentional action to mislead, misinform and/or undertake illegal activity can lead to a realisable threat.
Vulnerability Assessment Critical Control Point (VACCP)	An emergent approach comprising Horizon Scanning (QV) for 'clues' and 'actionable intelligence' relating to adulteration, substitution and supply chain integrity and suggest 'Thinking like a Criminal' and entering the mind-set of a criminal to identify opportunities for fraud and criminal activity.

Appendix 3: What works to prevent food fraud - definitions and meanings of food fraud

Successful prevention of food fraud is hindered if ambiguity concerning what food fraud is, and what the term means, still exists. Although food fraud dates back to ancient Greece and Rome and is still regularly operationalised, there is no agreed definition within academic literature or regulation. Due to the lack of a set legal definition of food fraud, there are inconsistencies among researchers and regulatory bodies with regard to what food fraud and related terms are as concepts and mean in practice (Wisniewski and Buschulte, 2019; Lotta and Bogue, 2015; Spink et al., 2015). A range of academic literature, government publications, and stakeholder guidance have defined food fraud, with examples presented in Table 3.1. Although within these sources definitions of food fraud often differ, as well as describing the types of food fraud that can occur, most definitions found in the literature agree that food fraud is an intentional and deceptive act primarily undertaken for economic gain associated with food or feed ingredients or products.

According to the FSA and Department of the Environment, Food and Rural Affairs (Defra), food fraud is defined as the act of "deliberately placing food on the market for financial gain, with the intention of deceiving the consumer" (Defra, 2014).

In addition to understanding what food fraud is, describing types of food fraud helps to determine how food fraud might occur in the food supply chain which will aid prevention and mitigation of food fraud. Food fraud has been categorised by type by many authors (GAO, 2009; Spink and Moyer, 2011; Manning and Soon, 2016; GFSI, 2017; Bouzembrak et al., 2018; Manning and Soon, 2019; CEN, 2019; NFCU, 2019a). While other publications have identified up to 38 types of food fraud, the NFCU (2019) however defines seven general types of food crime which includes some types of food fraud (Table 3.2). Wider food-related crime and food defence threats extend beyond food fraud, and there is a lack of consistency and clarity on what threats are included or exclude from a national or organisational FFPP. In the stakeholder interviews colloquial terms were used such as 'passing off,' 'ripping off,' 'swapping-out,' 'reboxing,' or 'misdescribing.' The terms used by interviewees to describe food crime and food fraud have been collated in Table 3.3.

Table 3.1: Exemplar Food Fraud definitions from the evidence base.

Source	Definition
Cruse (2019)	An intentional change in a food product that a consumer is unaware of with their purpose to deceive consumers- whether to cause harm or to economically benefit.
Manning and Soon (2019)	Intentional modification of food products and/or associated documentation for economic gain and may lead to issues of food safety, legality and/or quality depending on the activities undertaken or the agent(s) used.
Spink et al. (2019a)	Long Definition: Illegal deception for economic gain using food encompasses deliberate and intentional substitution, addition, tampering, or misrepresentation of food, food ingredients, or food packaging; or false or misleading statements made about a product for economic gain. The types of fraud include adulteration, tampering, product overrun, theft, diversion, simulation, and counterfeiting.
Spink, (2019); Spink et al. (2019a; 2019b)	Short Definition: Illegal deception for economic gain using food
BRC, 2018	Fraudulent and intentional substitution, dilution or addition to a product or raw material, or misrepresentation of the product or material, for the purpose of financial gain, by increasing the apparent value of the product or reducing the cost of its production.
BSI British Standards institution (2017)	Dishonest act or omission relation to the production or supply of food, which is intended for personal gain or to cause loss to another party.
CEN (2019)	Intentionally causing a mismatch between food product claims and food product characteristics.
EC (2018)	Food fraud is about intentional actions taken by businesses or individuals for the purpose of deceiving purchasers and gaining an undue advantage therefrom, in violation of the European Union (EU) agri-food chain legislation. These intentional infringements may also constitute a risk to human, animal or plant health, or to animal welfare or to the environment as regards genetically modified organisms (GMOs) and plant protection products. The EU Food Fraud Network refers to four key operative criteria to distinguish whether a case should be reported as a suspicion of fraud or as a non-compliance: 1. Violation of EU law codified in the EU agri-food chain legislation. 2. Intention 3. Economic gain 4. Deception of Customer
Foundation Food Safety System Certification (FSSC) 22000 (2019)	A collective term encompassing the deliberate and intentional substitution, addition, tampering or misrepresentation of food, food ingredients or food packaging, labelling, product information or false or misleading statements made about a product for economic gain that could impact consumer health (GFSI v7.2:2018).

An internationally recognised legal definition of food fraud and associated terminology (see Appendix 2) would represent a significant contribution and be advantageous for developing trade deals especially where food standards regulations vary from country to country. While a legal definition for food fraud is not strictly speaking necessary to combat food fraud, an agreed definition may still carry significant benefits in clarifying the regulators' intent and be conducive to ensuring consistent approaches across the food industry, and galvanising action and support for the chosen regulatory strategies.

Such a definition could bring clarity and focus on the fight against food fraud.

Table 3.2: Types of Food Crime as defined by NFCU (NFCU, 2019).

Forms of Crime	Definition
Adulteration	This involves adding a substance to a food to increase its weight or volume, or to improve its appearance or taste. For example, chilli powder may be spiked with cheaper and potentially harmful additives, or honey may be mixed with corn syrup.
Document fraud	This involves creating, altering, or using false or genuine documents, with the intent to deceive or pass specific controls.
Illegal processing	This involves slaughtering or preparing meat and related products in unapproved establishments or using unauthorised techniques.
Misrepresentation	This involves misleading consumers about the nature, substance, source, or quality of a food product. For example, a product may be labelled as "organic" or "non-GMO" when it is not, or a food may be marketed as being from a specific region or made with certain ingredients when it is not.
Substitution	This involves replacing a more expensive or higher-quality food with a cheaper or lower-quality substitute. For example, olive oil may be diluted with cheaper vegetable oils, or fish may be mislabelled as a more expensive species.
Theft	This involves dishonestly obtaining food, drink or feed products to profit from their use or sale.
Waste diversion	This involves illegally diverting food, drink or feed meant for disposal, back into the supply chain.

Terms used by interviewees to describe food fraud and food crime threats

- Adaption
- Addition
- Adulteration
- Authenticity
- Bribery
- Composition
- Corruption
- Counterfeiting
- Date coding
- Dilution
- Dishonesty
- Economically motivated adulteration (EMA)
- Excess claims
- Extortion
- Fair trade
- Forgery
- Hacktivism

- Lying

- Misdescribing

- Mislabelling

- Misleading

- Misrepresentation

- Nutritional labelling

- Over declaration

- Overrun

- Packaging

- Passing off

- Provenance

- Reboxing

- Replacement

- Replication

- Ripping off

- Similarity

- Smuggling

- Substitution

- Swapping out

- Tampering

- Terrorism

- Theft

- Under declaration

- Under weight

The BSI PAS 96:2017 Guide to protecting and defending food and drink from deliberate attack (BSI, 2017) defines a threat as 'something that can cause loss or harm and arises from the ill-intent of people.' Whilst multiple academic sources highlight the difference between food safety, food quality, food fraud and food defence; (see work of Spink cited in this report), in the interviews the terms 'hazard' and 'threat,' were used far more interchangeably and with more cross-over as shown in Table 3.3 and the codebook from the interviews (Appendix 7). For example, whilst smuggling, terrorism, or hacktivism, may be described in some academic sources as being food crime or food defence threats rather than food fraud issues, they were identified within the interviews as intentional acts of deception that were of concern, whether they were classically defined as food fraud or not.

Food fraud is associated with varying policy responses where 'food safety', 'food crime', 'food standards', 'food integrity', 'food authenticity', 'food security', 'food defence,' each imply different forms of regulatory action (Lord, 2017). These range from regulatory measures to persuade business to comply with prescriptive regulatory standards including self-regulation through to the

developing of sentencing guidelines and the criminal sanctioning of individual offenders. Underpinning this policy agenda is a need to prevent food fraud, food crime, and food harms, and to improve the integrity of the national food system. This outcome was central to the Elliot Review (Elliot 2014) into the integrity and assurance of food supply networks and the associated formation of the NFCU and FIIN. As Spink and Moyer (2011) note, '(w)hile classic intervention and response tactics have value whenever public health is threatened, proactive prevention is the logical progression' and this requires recognition that 'the root cause of food fraud has fundamentally different properties' to other policy agendas such as ensuring food on sale in the UK is safe.

Interventions for food fraud prevention strategies

VACCP and Enterprise Risk Management (ERM) were highlighted as a focus for strategies so they are comprehensive, robust, real-time and integrated (Moyer et al., 2017). Integration and a combination of effective identification and mitigation strategy and a well-coordinated supply chain system are essential to counter fraud (Everstine et al. 2018; 2020; Barnard and O'Connor 2017; Fassam and Dani, 2017). Harsher sanctions to neutralise expected economic gains of fraudsters, combined with whistleblowing facilities and improvements in electronic certification system in the food supply chain are all of value (Afrodita et al., 2018). Strategies for preventing fraud must evolve and be responsive to changes in tactics by the perpetrators of food fraud (Barnard and O'Connor 2017). Cadieux et al. (2019) suggest that establishing public-private partnership between the government, the industry and academia will help reduce fraud incidences. Applying penalties alone without joint efforts by stakeholders will be counter-productive. Gimonkar et al. (2020) propose collaboration among the stakeholders, stricter law enforcement and an effective management system associated with a vulnerability assessment plan.

Uncoordinated and disjointed efforts will sabotage the fight against fraud prevention. To prevent food fraud, stakeholders and government must work together and ensure that all preventive measures are in place. Brereton et al. (2016) suggest developing a FCMS with stakeholders' engagement is key to effective food fraud prevention. Manning and Soon (2019) propose collaboration between profit and non-profit sectors to build up information sharing.

Intelligence gathering, information sharing and surveillance

Luijckx et al., (2021) propose intelligence gathering, risk assessment and risk management control are combined to aid fraud prevention. Using fraud detection methods without carrying out real-time supply chain mapping and fraud assessment will 'not work' due to the transitory nature of food fraud activities. It is important to identify at which stage within the supply chain fraud is likely to occur and when, to develop and adopt fraud mitigation measures that will be effective (Luijckx et al., 2021). Brooks et al. (2017) propose intelligence gathering and sharing of information among the stakeholders and adequate funding of relevant agencies involved in food fraud mitigation. Elliot et al. (2019) discuss the foundation for an understanding of the fraud opportunity utilising holistic and all-encompassing information sharing systems.

They also highlight the need for more guidance or harmonisation on vulnerability assessments, strategy development and management, and correlation to all other enterprise-wide risks (ERM/COSO). Da Silva et al. (2018) propose a comprehensive food fraud and adulteration prevention programme which requires the enforcement of regulatory systems, increased sampling and monitoring, training of food producers and handlers, and development of precise, rapid, and cost-effective methods of fraud detection. The availability of robust methods to identify the chemical constituents of foods is also a decisive step, both to detect and prevent fraud and to open up new markets to these products.

Use of technology

Food fraud prevention needs effective new approaches by building digital traceability capacity into the supply chain system. An integrated approach to counter fraud, implement a fraud classification scheme (fraud identification and mitigation) 'will work' (Everstine et al. 2018). A combination of new technologies (Blockchain, IoT, AI and big data) deployed simultaneously will work well in fraud prevention (Danese et al. 2021; Hassoun et al. 2022). Fang and Stone (2019) propose the use of blockchain to guarantee food product data integrity and to prevent the incidence of product misrepresentation. The operation of voluntary technology-based systems that go beyond legal requirements is promising to ensure food traceability (Garius and Treibmaier, 2021) guarantee food product data integrity and prevent incidence of product misrepresentation (Daniel et al., 2022). Alzahani and Bulusu (2018) propose combining Blockchain and Near Field Communication (NFC) technologies to prevent fraud; and Alkhudary et al. (2022) highlight a supply chain system supported by Blockchain technology, IoT sensors and an ADRM system.

A one size fits all approach does not work in fraud prevention. An integrated approach is needed which requires the combination of several prevention interventions to form an effective strategy. Bager et al. (2022) propose the digitisation of supply chain systems to assure transparency and traceability and highlight that it is important to understand the technicalities of Blockchain technology before it can be deployed for fraud prevention. Disjointed and uncoordinated supply chain systems will not work in fraud prevention (Collart and Canales, 2022).

Industry, government (central and local), and academic collaborating together can support food fraud detection. Examples of this collaboration include the co-creation of incident databases, but this approach is not specifically aimed at fraud prevention. However, many databases are 'pay-to-access' leaving micro, small and medium sized businesses (MSMEs) with minimal access to databases or guidance. The Food Industry Intelligence Network (FIIN) is an example of collaborative best practice in the UK. The Defra Review of Food Fraud Drivers and Mitigation Tools Project in a data collection period between 2018 and 2021 and published in 2023 identified the five most commonly used databases. These were the European Rapid Alert System for Food and Feed (RASFF) Safety database and within the UK the UK Food Surveillance System (UKFSS); HorizonScan - Fera Science; and the Local Authority Enforcement Monitoring System (LAEMS) Database.

Creating a public platform to underpin food fraud prevention through greater access to information and simple diagnostic tools for MSMEs is essential. The creation of food fraud databases from text mining academic and media sources and the creation of a risk pathfinder system that combines data supports detection of likely food safety and food fraud events (Tao et al., 2020).

Davidson et al. (2017) suggest that food safety integration with food defence works well in prevention. The inclusion of food fraud specifically in HACCP and carefully defining different forms of food fraud and other food crime, for example, adulteration and contamination, is important (Manning and Soon, 2016). This is explained within the main report. Esteki et al. (2019) consider the integration of food fraud risk system into food management system coupled with the implementation of fraud prevention policies and strict enforcement of existing legislation. Clearer product traceability, transparent market interaction and assured supply chain integrity will also prevent the incidence of food fraud (Ehmke et al., 2019). Strengthening of a harmonised FCMS will be a key enabler for an effective food supply chain response (Cawthorn and Mariani, 2017).

Use of modelling techniques can help to predict and prevent food fraud for example, Bayesian network modelling linked to the RASFF database (Bouzembrak and Marvin, 2016). Djatna et al. (2020) also propose product data modelling and an associated information system supported by blockchain technology and the use of smart contract system as being effective for fraud

prevention. Higher financial penalties and open data publishing of food fraud perpetrators might also be effective in fraud prevention (Bimbo et al., 2019).

Developing food fraud awareness amongst consumers will also support prevention strategies (Bitzios et al., 2017). Lee et al. (2022) propose that efforts should be made to create consumer awareness about precautions when purchasing products using online vendors and receiving seemingly legitimate but malicious ads or links via unsecure chatting apps. They suggest the use of various forms of technologies to digitally trace and authenticate food related products would strengthen the level of surveillance and, in turn, increase the likelihood of detecting suspicious activity.

Upstream prevention through supply chain assurance is recognised as a key strategic focus for food fraud prevention. Upstream and downstream food fraud countermeasures can be effectively implemented wherein the focus should be holistic, comprehensive, and on integrated solutions. Supply chains/networks need to be more visible to identify existing and emergent vulnerabilities and be mapped according to specific attributes. The Defra Review of Food Fraud Drivers and Mitigation Tools Project highlighted supplier approval processes and supply chain verification tools as key food fraud mitigation strategies. They also link to project management lifecycle software and forensic accounting as key strategies to adopt.
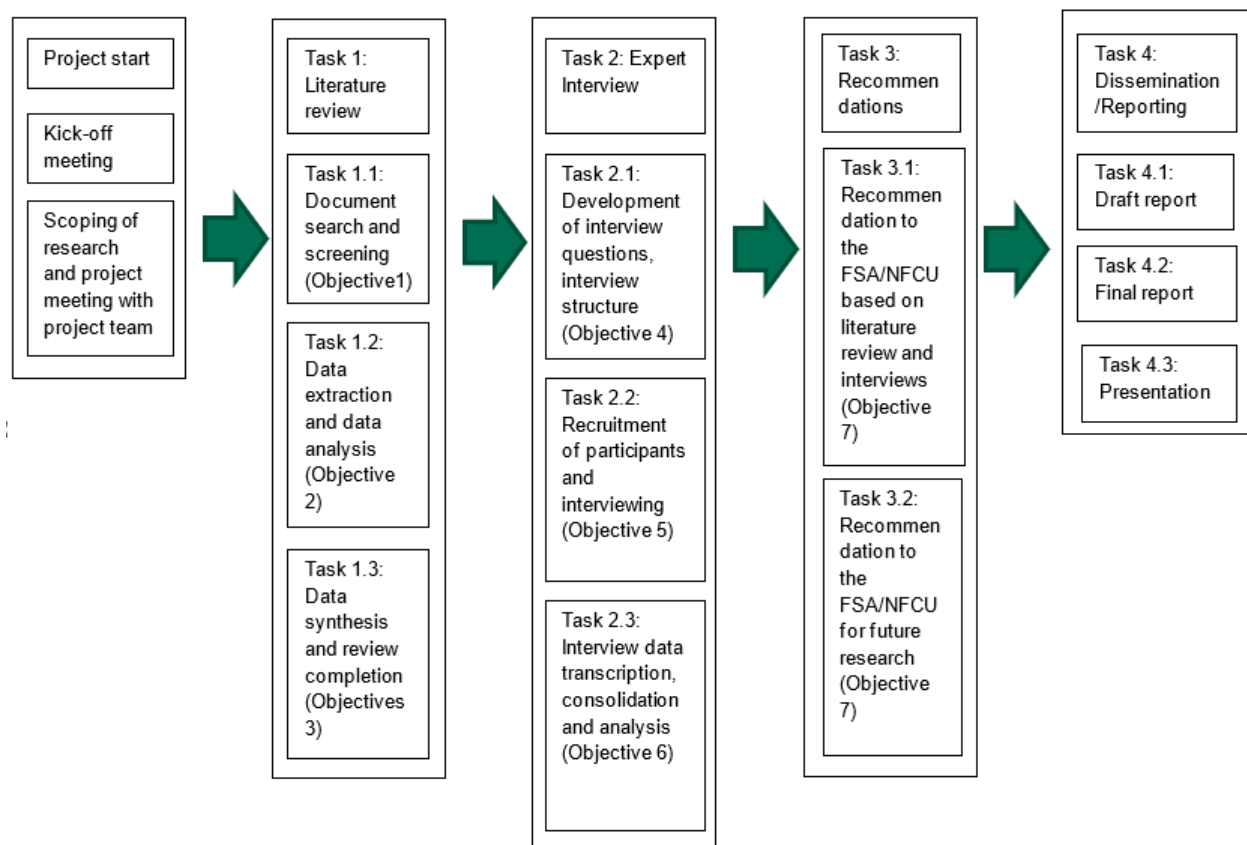
Verification activities identified in this research include the monitoring of: financial flows, waste flows (especially where waste products could be potential adulterants), product integrity, process integrity, human integrity, data integrity and establishment integrity. Mass balance analysis and traceability assessments as means of verification are essential within this upstream/downstream prevention approach. The dominance of the multiple retailers and third-party certification such as the BRC Global Standard is effective as an approach in developing FBO certifiable food safety management systems. However, vulnerabilities can arise if adoption strategies are based upon compliance with the standard at the expense of more bespoke (contextually specific) approaches to FCMS focussed specifically upon the prevention of food fraud. Verification including inspection and auditing processes should not be limited to compliance with FCMSs but should verify the efficacy of the FCMS as a proposition to identify, eliminate and/or mitigate food fraud, and promote food integrity.

Appendix 4: What works to prevent food fraud - full methodology

Our study workflow was split into four tasks (Figure 4.1):

- Task 1. Carrying out a literature review on domestic and international evidence
- Task 2. Conducting supplementary expert interviews to understand 'what works' or 'what may work' in preventing food fraud
- Task 3. Providing recommendations which could be adopted by the NFCU and incorporated into the Unit's key strategies and for any future research required within this area
- Task 4. Reporting and dissemination of the final report

Figure 4.1: Diagram of study workflow and tasks

Project start

Kick-off meeting

Scoping of research and project meeting with project team

→

Task 1: Literature review

Task 1.1: Document search and screening (Objective1)

Task 1.2: Data extraction and data analysis (Objective 2)

Task 1.3: Data synthesis and review completion (Objectives 3)

→

Task 2: Expert Interview

Task 2.1: Development of interview questions, interview structure (Objective 4)

Task 2.2: Recruitment of participants and interviewing (Objective 5)

Task 2.3: Interview data transcription, consolidation and analysis (Objective 6)

→

Task 3: Recommendations

Task 3.1: Recommendation to the FSA/NFCU based on literature review and interviews (Objective 7)

Task 3.2: Recommendation to the FSA/NFCU for future research (Objective 7)

→

Task 4: Dissemination/Reporting

Task 4.1: Draft report

Task 4.2: Final report

Task 4.3: Presentation

Literature review

The literature review had a comprehensive search strategy (as shown in Figure 3.2) considering all available evidence in the public domain, including peer-reviewed articles, grey literature (for example, government and industry reports), relevant government reports, European and International literature. This included previously published systematic and critical reviews, and relevant assessments, as well as primary research.

The main review questions were:

1. What food fraud prevention strategies and initiatives have been implemented in the UK and other countries?
2. What strategies/initiatives have been implemented to prevent and tackle commodity based fraud in other industries?
3. What conditions need to be in place to enable fraud prevention strategies to be successful?

The key elements of the question (PIO): Population (P), Intervention (I), and Outcome (O), were:

- The population of interest included food and non-food physical products sector.
- All fraud interventions or prevention strategies used in food and non-food physical products sector.
- Relevant outcome measures for interventions or prevention strategies were what impact did the intervention or prevention have on fraud.

All fraud prevention strategies and initiatives were considered across sectors.

The primary source databases searched were Web of Science, Scopus, and EBSCOhost. The searches were restricted to records published from 1970 to December 2022. Finalised keywords agreed with the Agency and were:

Arts OR Banking OR Commodity OR Document OR Feed OR Financial OR Food OR "Food Crime" OR "Food Fraud" OR "Food Standards" OR Goods OR "Health care" OR Industries OR Ingredients OR Institutions OR International OR Manufacturing OR Medical OR Medicine OR Pharmaceutical OR Services OR "Supply chain" OR Waste

AND

"Anti-fraud" OR Block OR "Campaign against" OR "Capable Guardians" OR Challenge OR CLEO OR CLUE OR Combatting OR Control OR "Food Crime Hotline" OR "Food Fraud Vulnerability Assessment" OR "Horizon Scanning" OR Intelligence OR "Intelligence Network" OR Interception OR Intervention OR MEMEX OR Policing OR Prevent OR Preventing OR Prevention OR QUACCP OR "Quality Assurance" OR "Routine Activity Theory" OR "Six Sigma" OR "Statistical Process Control in Food Industries" OR Stop OR TACCP OR Tackle OR VACCP

AND

Adulteration OR Authentic OR Authenticity OR Counterfeiting OR Crime OR Diversion OR "Economically motivated adulteration" OR Fake OR Fraud OR Illegal OR Integrity OR Misrepresentation OR "Natural Quality" OR "Substance Quality" OR Risk OR Substitution OR "Supply chain vulnerability" OR Tampering OR Theft OR Traceability

Focused Google searches were used to identify relevant grey literature.

In total 39,132 citations were initially identified in Web of Science, Scopus, and EBSCOhost. There was considerable overlap between the databases with 20,406 duplicates. Additional records were identified through Google searches, other references, and through contact with authors. For all searches, citations and abstracts were uploaded from each of the electronic databases into Covidence (an online tool for systematic reviewing). The following exclusion criteria were applied:

- They contain no relevant data on strategies for fraud or crime prevention.
- Were in a language other than English.

The criteria were independently applied to the abstract of each paper by at least two members of the seven-member project team. For each citation, a consensus was reached that the citation is relevant for inclusion. Arbitration by a third member of the project team was used to settle conflicting appraisals. 18,726 abstracts were screened, and 17,494 references excluded. Full texts were obtained for all abstracts that passed the inclusion criteria.

A total of 915 publications were considered relevant by title and abstract and full texts collected for second screening. This number was reduced to 151 publications from which some data were extracted, with 703 references being excluded because they were not relevant. An in-depth content analysis of the selected articles was carried out. With the key elements of interest from each paper extracted. To synthesise the data extracted and evaluate its quality a narrative approach was used. This was used to; a) develop a synthesis of findings of each article, b) investigate relationships within and between articles, and c), evaluate the degree of robustness of the synthesis.

Figure 4.2: Flow (PRISMA) diagram of the selection and exclusion of articles related to the scope of this review
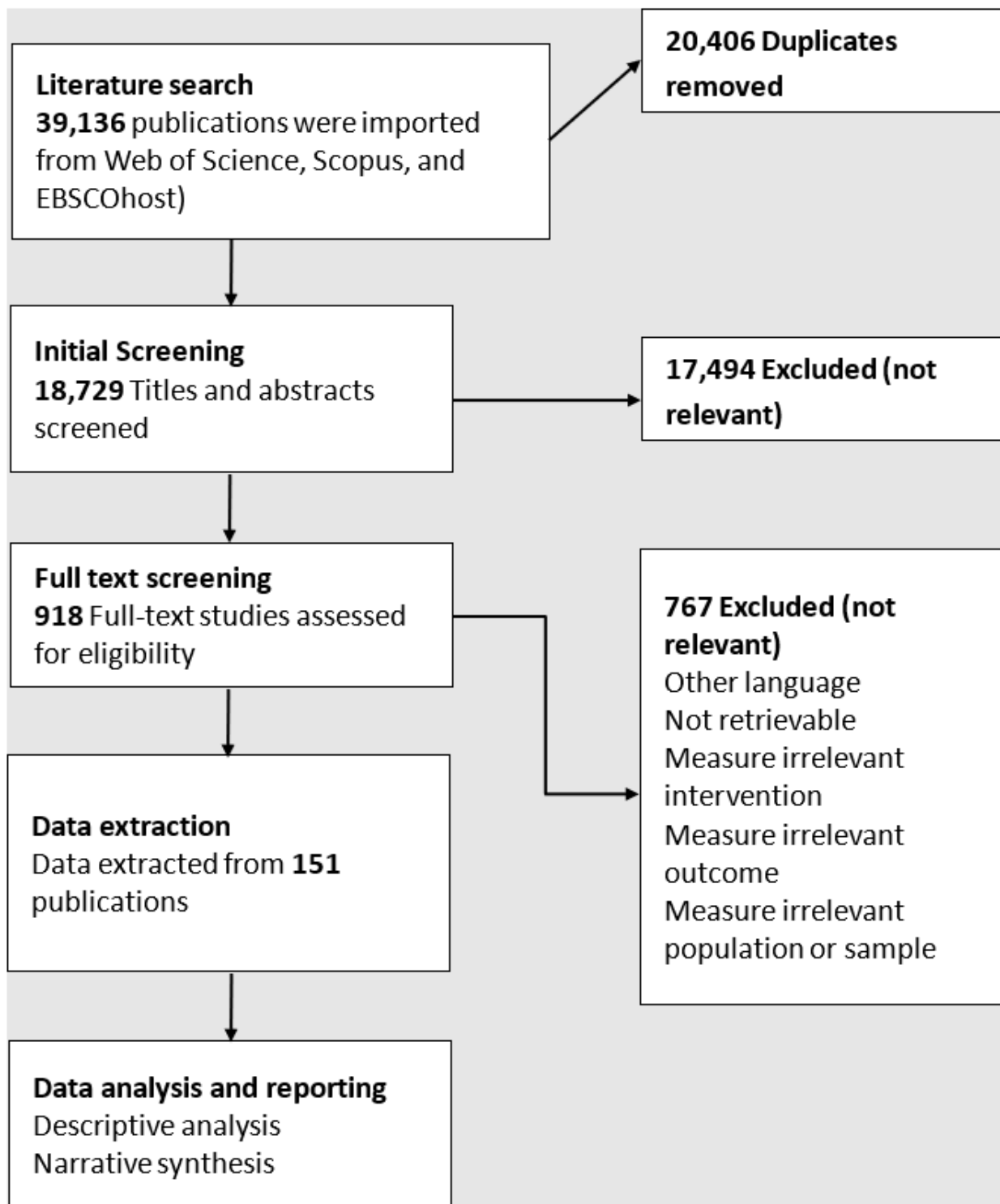
Interviews

In parallel to the literature review, a series of semi-structured interviews with professionals working on food fraud/crime were carried out. The purpose of the interviews was to get an in-depth understanding of what is currently going on around food fraud prevention and what can be done to improve prevention practices across the sector. The differences between detection and prevention where also discussed at some length.

Development of interview questions, interview structure

An interview protocol was created based on various topics that emerged from the evidence review that was conducted prior to the interviews (Appendix 4). The overall research aims, and research questions highlighted in the review section were put into consideration when developing the interview protocol and questions.

Before the online video interviews commenced the interview questions and interview protocol document was submitted to the University of Lincoln ethics department for ethics approval and to the FSA for review and approval.

Recruitment of participants and interviewing

We utilised a non-probability purposive sampling technique for the selection and recruitment of participants for the interview component of this study. This is a well-known sampling technique for the identification and selection of participants and proven to be the most effective when there are limited resources (Patton, 2002). Based on the expertise and experience of the members of the project team, decisions were made on which organisations/individuals to be interviewed. In the selection of international and domestic participants we ensured as best as possible to include representatives from Official Controls, the regulators (Environmental Health/Food Crime Units where relevant), industry representative bodies, industry network (such as the Food Industry Intelligence Network (FIIN)), policymakers and experts (such as academic, researchers, consultants).

Some participants worked in senior roles for multi-national companies involved in the food industry and others worked for SME food companies. We also interviewed accountants involved in auditing the food sector, individuals working in laboratories testing food, and individuals working for Local Authorities, NGOs, and organisations such as the WHO and UN.

A total of 16 in-depth semi-structured virtual interviews were conducted as part of this study. Each interview lasted for around 90 minutes. For the interviews, qualitative research methods allowed collection of in-depth information directly from the interviewees covering agreed question areas/topics while also giving the interviewees the opportunity to expand on their responses as they felt appropriate.

Prior to the interview a pilot interview was conducted (Steinar, 2007) which assisted in the refinement of the final interview questions/topics. Identified potential participants were contacted and interview dates and times were agreed. Interviews were conducted with two research team members being present. Participants' consent for the interview and the recording of the interview was confirmed and agreed before the interview.

Interview data transcription, consolidation, content and thematic analysis

All interviews were recorded and then transcribed in Microsoft Teams. The interview transcription was checked after each interview by one of the research team for completeness and accuracy. Once the transcription has been reviewed it was anonymised and emailed to the participant for confirmation Content analysis of the transcribed interview was used to identify specific vocabulary and language through open coding using NVivo (Miles and Huberman, 1994) and the patterns and themes that emerged from the text were drawn out (Schreier, 2012). Axial coding brought the open codes together following the work of Braun and Clarke (2021) namely 1) data familiarisation; 2) systematic data coding; 3) generating initial themes; 4) developing and reviewing themes; 5) refining, defining and naming themes; and 6) writing the report.

Appendix 5: What works to prevent food fraud- interview protocol

Specification note on In-depth Interview

Interviews with domestic and international experts, including representatives from organisations which have established fraud prevention strategies.

Interviews will provide an opportunity to identify relevant detailed examples of where fraud prevention strategies/initiatives have been implemented. The findings from the interviews will be triangulated with the evidence gathered in the evidence review. We anticipate that up to 15 interviews could be conducted to allow for a range of international and domestic food and non-food focused organisations to take part.

We propose that a purposive sampling approach is taken. In your response, please outline your proposed approach to sampling, recruitment and the number of interviews you propose conducting to obtain the evidence required to answer the research questions.

The aims of this research are to:

- Investigate strategies for the prevention of food fraud which have been successfully utilised in other countries and organisations outside of the FSA (both within the UK and internationally);
- Understand what has worked well in preventing food fraud and the lessons learned from these initiatives/strategies;
- Understand what has worked well in preventing fraud in other commodity/ physical goods based industries (for example, pharmaceuticals) and the lessons learnt from these strategies;
- Provide recommendations which could be adopted by the National Food Crime Unit's (NFCU) and incorporated into the Unit's key strategies;
- Provide recommendations for any future research required within this area.

Interview Protocol

Prior to Interview:

Research Participant Information and Consent Form will be sent to the participant.

The Consent Form should be received back latest on the morning of the agreed interview day.

On the Interview day:

The Lead and Second Interviewer should arrive on MS Teams or other agreed platform before the scheduled interview to run through the protocol and questions before the interview starts.

All: Welcome and introductions

- Lead interviewer: Appreciate the interviewee for agreeing to participate.
- Lead Interviewer: Ask if interviewee have any questions before the interview starts and check online consent form has been returned once everyone if happy, recording can begin. Also discuss coffee break plans before commencing the interview.
- Participant: Can switch off their video camera if they feel more comfortable with this.
- Lead interviewer or Lincoln Staff: Start recording
- Set out scope of research.

- Briefly reiterate the scope of the research, what the aims of the project are and what we hope to achieve at the end of the interview/research.

Background questions (these can be collected before the interview)

- **BQ1:** Tell us more about your organisation as well as your role within it.
- Follow-up if participant is from industry: Which country are you in/what good does your company manufacture
- **BQ2:** Tell us a bit about how your organisation/company combats fraud.
- Follow-up: How many people/departments work on this issue?
- **BQ3:** How has combating food fraud and fraud more generally changed in recent years?

Leadoff Question

- **LQ1:** What is your understanding of fraud?
- **LQ2:** Tell us about some examples you have come across.
- **LQ3:** Tell us a bit more about fraud prevention and fraud detection.
- **LQ4:** What differences do you think there are between fraud detection and fraud prevention?
- **Follow-up:** Do you see a clear difference in the two terms? Could there be an overlap (i.e. would you consider real-time detection, a prevention strategy?)Different stakeholders may have different meanings for prevention and detection - would be good to capture.

Main questions

- **MQ1:** How does your organisation prevent/detect fraud?
- **MQ2:** What is/are the strategy(ies)/initiative(s) based on? Also ask about whether the strategy is reactive, proactive, random, targeted, or non-targeted?
- **MQ3:** What are the aims and objectives of these strategies and initiatives?
- **MQ4:** How does your company operationalise its fraud prevention strategy/policy?
- **MQ5:** What are the main objectives of your fraud strategy/policies? For example, non-conforming items entering the supply chain or from getting to the consumer or both?
- **MQ6:** What weighting does your fraud prevention strategies place on things such as Do your strategies include analysis of the causes and the opportunities for Food Fraud (for example, Food Fraud Vulnerability Assessment (FFVA)) analysis of the human factors such as Company Culture, pact of motive and opportunity for example, education and training? of your management and workforce?
- **MQ7:** How is your fraud prevention strategy/policy implemented?
- **MQ8:** How do you collaborate with other organisations (within the supply chain) to minimise fraud?
- **MQ9:** Which fraud prevention strategies/initiatives have worked?
- **MQ10:** What factors have made these strategies/initiatives particularly successful?
- **MQ11:** What challenges do you/your organisation face while trying to prevent fraud and how are these challenges overcome?
- **MQ12:** Which strategies/initiatives have not worked? Why?
- **MQ13:** What factors have made these strategies unsuccessful?
- **MQ14:** What lessons have you learnt from the unsuccessful initiatives?
- **MQ15:** What recommendations can be applied to future strategies?
- **MQ16:** What conditions need to be in place to enable fraud prevention strategies to be successful? (Note conditions might be related to guardians or hurdles (hard for example, infrastructure or soft for example, procedures or policies)
- **MQ17:** What is your view on the ability of current Audit practice (Methods and Techniques) both internally and externally to verify FCMS in terms of the causes and the vulnerabilities

of/to food fraud.

Questions Current Government strategy (for UK based organisations only)

- **GQ1:** How familiar are you with the UK's food fraud prevention strategies.
- IF ANSWER TO GQ1 IS "YES" PLEASE PROCEED TO GQ2 IF "NO" PLEASE PROCEED TO PART 7.
- **GQ2:** How active have you been in collaborating with the National Food Crime Unit (NFCU)?
- **GQ3:** What has affected how you engage with the NFCU?
- **GQ4:** In your opinion, how important is intelligence sharing to successfully tackle food fraud? Are you aware of any successes in tackling Food Fraud that have come from intelligence sharing?
- **GQ5:** What more can be done to improve and optimise the current government strategies/initiatives?
- **GQ6:** In your opinion, what does government need to do to improve/address Food Fraud?
- Could Official Controls (i.e. the work of Local Authority Environmental Health Depts and Official Veterinarians) better address Food Fraud? If so please share you view of how this might be realised.
- **GQ7:** How can we learn lessons from other sectors?
- **GQ8:** What question(s) have we not asked that we should have asked?

Follow-up questions

- Any question that participant want to get back to us on as they can provide more detail, and any additional comments from the participants.

- Participants to be reminded that they can contact us if they remember any other useful point(s) or information they would like to share further.
- Closing remarks
- Thank participant.
- Stop recording

After the Interview:

Lead Interviewer or Lincoln staff should download interview transcript and check for obvious errors. Project Lead to send transcript to participant for confirmation details are accurate. Participant to confirm interview transcript within 7 days of receiving transcript.

Appendix 6: What works to prevent food fraud - exemplar quotes from the interviews

Exemplar quotes from interviews on national strategy

Experience

In terms of what we think the NFCU should do in terms of prevention, so you realise that they have started from a very low base that they've gotten now 80 plus staff in the NFCU which is

great, but the vast majority of them are with the criminal policing background and (have) very little food experience.

It probably takes in the region of four to five years of joining the service with no background in in trading standards to even be looking at taking a food qualification. It's (food related experience) not something that we can quickly replace.

Guidance

Having something like that (guidance) which is accessible I think would be really useful to overcome the challenges. I'm not saying the investment in something the size of safer food, Better Business, but something more compact.

It's not very easy to find information on food fraud, but it's also not very easy to find information on food safety.

Prevention versus detection

I would see fraud prevention as being a more proactive approach, whereas fraud detection is more an intelligence-based approach to things in which you may be using techniques such as sampling to uncover issues.

Once you've understood the risk then put a mitigation strategy in around the risk that you can control.

Training

I'm trained to track bacteria and work out hazard analysis and things like that, and I can turn that skill, it's a transferable skill from hazard analysis to vulnerability assessment.

There are some councils who are geared up for it (food fraud) and some who are not, so I would suspect information's coming in, but it's not being acted on and it's to do with a lack of structure. It's a lack of training, a lack of understanding.

So we run this course to just kind of raise awareness of food fraud and it really, genuinely isn't something they've (micro and small businesses) thought about before because they they've always had this mindset that they're buying it and what they buy is what they buy.

Exemplar quotes on opportunities, motivation, supervisory measures, often described as countermeasures in the academic literature and impact

Impact

When we're in a caterer if that fish is cod, or if that fish is haddock, it's not necessarily gonna kill anyone. It's not going to make someone ill depending on whether it's cod or haddock or in a high end caterer, whether it's hand caught scallop or whether it's dredged. So in terms of food fraud, I do think that there's a danger that these things get relegated in terms of their importance, when we're when we're dealing with a business.

But if they're not complying with trading standards legislation, chances are they're not gonna be compliant with EHO regulations as well or health and safety, (or) fire regulations.

Motivation

We talk about it being economically motivated.

Because they've worked hard to get that customer, it's a highly competitive market and they don't want to let that customer down with the delivery because that customer would simply go elsewhere.

But I would say and for the next 12 months when energy costs are pushed up and their margins are getting tighter and tighter and tighter, if they can save some money by buying something at the back door…

Opportunities

If there's an opportunity there to make money on the side, some of them will.

Supervisory measures

One of the best ways of reducing the potential for food fraud is to go around your business and actually look at where all the places physically in the business, where food fraud could take place and how to engineer them out?... So all the incoming points to my factory are sealed off. All the pipes are sealed off properly.

The only thing that I've seen is for the site itself where they have thumbprint recognition to get onto site for some of the medium size sites.
Our systems that we have in place it it's about making sure that we've got very clearly defined processes and procedures and that's backed up with the training.

Exemplar quotes on organisational culture, behaviour, and management integration within FFPPs from the interviews

I think it starts at the top because if they're not interested then it's not really going to happen. So, I think if anything that we do begins like that and ethics all starts with our board.

So we send out a horizon scan newsletter every month that goes to the entire business, including the board. And then we also do one every quarter, just update the business where we are, how we're doing, what we're looking at.

At the end of the day, the technical guys don't buy the xxx. You know, the procurement team buys the xxx, you know so. So, if you haven't got those guys engaged and then you haven't got the operational guys engaged, who are actually making it into a product. You know it's not gonna work.

And then this is all about the culture of a business and the fact that, you know, the leaders have to live and breathe the companies' mission statements... a positive attitude to food safety and Food Standards so that people take pride in their work. And that's been much more effective in preventing, you know, individual criminality.

In terms of wider assessment of human factors in food business such as the culture of the business and your sense of the culture of the business, naturally intending to comply or not comply. What sort of cues do you pick up from businesses when you go into them, where you might then reflect on their culture, their degree of willingness to comply, level of food safety education, things like that.

And you know from a fork truck driver in a warehouse to the MD, we're all part of the team. We're all doing a different job. But the big, the big thing for me is we're all in food production.

Appendix 7: What works to prevent food fraud - codebook for the interviews

Alternative sectors

Name	Importance: Level 1	Importance: Level 2	Importance: Level 3
-	cyber crime	-	-
drugs	Drugs	doping in sport	-
fashion	clothing; handbag	-	-
finance	accounts; accounting software; banks; digital fraud; software; tax evasion	backup protocols; credit rating; cutoff test	-
one health	public health; pharmaceutical	pharmacovigilance	-
tobacco	illicit tobacco; smuggling tobacco	-	-

Challenges

Name	Importance: Level 1	Importance: Level 2	Importance: Level 3
external drivers	BREXIT; cheap food; cost of living crisis; COVID; currency variations; impact of austerity; natural disaster - for example,: floods; political stability; price stability; supply shock/shortage; trade deals; war/conflict	-	-
lack of agility	lack of flexibility with rituals; lack of interconnectivity; lack of operationalisation	challenging status quo; contractual inflexibility; inspection myopia; normalisation; over-complex; ways of working	Checklist; ticking a box
lack of awareness/understanding	lack of communication; lack of familiarity; lack of guidance; lack of interoperability; lack of knowledge; lack of understanding	disclosure; ignorance of law; jargon	-
lack of information	lack of benchmark; lack of definition; lack of real time information	lessons	-
lack of resources	consolidation of laboratory services; cost of designing of predictive systems; cost of implementing predictive systems; lack of capacity; lack of equipment; lack of food experience; lack of food qualified officers; lack of funding/budget; lack of surveillance tools; lack of training	commercial decision; maintaining existing competencies; poor use of resource; poor response time for sampling reduction; informal sampling; sampling gaps; staff turnover	too busy with the day job
lack of structure/standards	lack of statutory driver; lack of stringency	poor level of enforcement	-
lack of trust	building trust; failure of trust	Trust	trustworthy

Recommendations

Importance: Level 1	Importance: Level 2	Importance: Level 3
connecting the dots	better external communication National Food Crime Unit (NFCU); additionality in data sharing; ecosystem for verification; good supplier relationships; international harmonisation of definitions; invest in communication; invest in technology; invest in testing; invest in training; invest in transparency; invest in trust; mapping the landscape; raise the bar to entering the food system; raise the bar to stay in business; real-time information for businesses; real-time information for environmental health officers (EHOs); ring fencing funding	adapted solutions; foreign supplier verification programme; payment for food like feed enforcement. Minimum training standards; minimum capability of controls

Elements of a Food Control Management System

Name	Importance: Level 1	Importance: Level 2	Importance: Level 3
Appropriate technologies/tools	analogue tools	paperwork; pen and paper; records	-
Appropriate technologies/tools	analytical techniques	authentication techniques; bioinformatics; chromatography; DNA testing; fatty acid profile; forensics; genetically modified organization (GMO) testing; isotope analysis; next generation sequencing; nuclear magnetic resonance (NMR); spectrometry (mass spectroscopy); x-rays	-
Appropriate technologies/tools	automation mechanisation, digital systems and IoT	apps; blockchain; data mining; digital platform; digital tools; digital traceability; drones; early warning systems; handheld devices; holograms; QR codes; tagging; tamper evident packaging; tamper proof seals	human technology interface; interoperability; signal
Culture	company culture; food fraud culture; food safety culture; mission; quality culture; shared values	audit rituals; human factors; positive culture; work environment	altruistic; aspiration; brand identity; ethics
Culture	economic culture	cost benefit analysis; economic climate; financial constraints; market dominance	financial records; margins; profit
Evidence, data, intelligence information	Data; databases; information; intelligence; incidents	commercially sensitive information; complaints (product recalls, scandals); credible sources of information; industry intelligence; information flow; information nodes; information sharing; intelligence filtering; intelligence gathering; intelligence led; procurement intelligence; Rapid Alert System for Food and Feed (RASFF) database	-
Evidence gathering	Auditing; observation; monitoring; surveillance; sampling; testing; triangulation; validation	audit depth; audit process; audit scope; audit standard; auditing standards; independence of audits; systems auditing unannounced audits; formal sampling; purposive sampling; random sampling; risk based sampling; suspect sample; surveillance programme; first, second, third party audits; traceability	audit reports; company check; in house surveillance; markers; metrics; objective evidence; routine checks; screening; scoring; snapshots; social media; spot checks; supplier reality check; trigger; whistleblowing; tracking tracing;
food crime	black economy; black markets; bribery; corruption; forgery; grey markets (grey imports); human (child labour, modern slavery, trafficking); illegal butchery; racketeering; theft (cash/stock); trademark infringements	illicit food system	the fake factory
food defence	bioterrorism; cyber crime (for example, ransomware); malicious contamination; malicious tampering	-	-
Food fraud	fraud detection	food fraud detection strategies; sampling strategy	Reactive; targeted (DNA speciation, chemical testing); untargeted
food fraud	food fraud diamond	competition; consequences; deterrence; ease of committing fraud; economic gain; getting away with it; motivation; opportunities; power/powerless; pressure (social pressure); rationalisation; situation	food fraud awareness; definition of fraud; intentional vs unintentional (mistake); value of ingredient/added value;
food fraud	food fraud management	food fraud mitigation; food fraud strategy	external fraud; internal fraud; generic fraud protocols; site level fraud protocols; specific fraud protocols;
food fraud	food fraud prevention		
food fraud	illicit food system	the fake factory	liability, litigation, fines sentencing
food fraud	perpetrators	criminal; fraudster; insiders; mafia (organised crime groups); offender	disgruntled employee; lorry drivers; occasional; occupational
threat agent	colours; insecticide; horsemeat; melamine; methanol; medication	carotenoid; copper sulphate; Sudan dyes; ethylene oxide; fipronil; nitrofuran	-
threat characterisation	addition (for example, water); adulteration; authenticity; composition; counterfeiting; deception; dilution; extortion; hacktivism; mislabelled; misrepresentation; negligence; smuggling; substitution; replacement; tampering; terrorism	adaption; accessing illegal waters; cheating; claims fraud; deliberate; desiccation; dishonesty; economically motivated adulteration (EMA); excess packaging; fake product; infractions; misdemeanours; misdescribing; misleading; misuse; overrun; passing off; provenance (country of origin; geographic origin; protected geographic indication (PGI)); reboxing; replication; ripped off; similarity; swapping out; too good to be true	-
threat target	alcohol	Alcohol by volume (ABV); champagne, gin spirits, vodka, whiskey, wine	-

Name	Importance: Level 1	Importance: Level 2	Importance: Level 3
threat target	fish and shellfish		
threat target	Honey	Manuka honey	-
threat target	Meat	Aberdeen Angus beef, Welsh beef, Chicken; composite meat; condemned meat; ham; kebabs; poultry; Scottish beef; Scottish lamb; Welsh lamb; Stornaway black pudding; turkey ham	-
threat target	miscellaneous: animal feed and pet food; baby food CBD, chocolate, cocoa, coconut milk, eggs, food supplements, fruit juice, gluten, salt, Sicilian lemon, veterinary medicines	-	-
threat target	Nuts	cashews, ground almond, pistachios	-
threat target	Oil	olive oil, sunflower oil	-
threat target	Rice	basmati rice, risotto rice	-
threat target	Spices	cinnamon, cumin, madagascan vanilla, paprika, saffron, turmeric	-
food integrity	data integrity	aggregated data; anonymised data; data access; data analysis; data characteristics; data collection; data consolidation; data driven; data ethics; data governance; data platforms; data sharing; data trusts; data versus metadata; databases; digitalisation; granularity; managing data; non-targeted data; people data; personal data, unstructured data	Data
food integrity	people integrity	Equity; honest; walks the walk; decision making; mindset	emergent thinking; old thinking
food integrity	process integrity	animal welfare; environmental; food waste; GMP; good practice; standards; procedures; standard operating procedure; opacity;	halal; religious standards; retailer standards
food integrity	product integrity	product analysis; product fingerprinting; product sampling; product scanning; product testing; product quality; product inspection;	-
Food quality	Failure prevention versus detection	failure detection; quality failure; failure prevention; prevention gap; quality control; raw material quality assessment; specification; statistical process control	-
Food safety	food safety management	allergen controls; cadmium; conditions; due diligence; E coli; food hygiene; food poisoning; Clostridium botulinum; forever plastics; glass; mineral oils; palm oil; reasonable precautions; hygiene controls;	-
Guardians	supply chain guardians	abattoir; auditor; board of directors; brokers; butchers; buyers; caterers; co-packer; consolidators; consumer; consumer services; distributors; engineers; factory manager; farmer; fast food; food business operator (FBO); food manufacturers; food service; food technologist; maintenance team; management team; manager; managing director; micro, small and medium sized enterprises (MSMEs); official veterinarians; procurement staff; production staff; quality control staff; quality manager; restaurants; retailer; shop floor; takeaways; technical manager; technical staff; wholesalers	-

Name	Importance: Level 1	Importance: Level 2	Importance: Level 3
Guardians	Stakeholder guardians	accountants; accreditation body; auditor; British Retail Consortium (BRC); business associations; Campden BRI; Centres of Expertise; certification body; Codex; competent authority; consultants; EHOs; Eurofins; Europol; FERA; FIIN; Food Authenticity Network; food cluster groups; FSA; FSS; general public; GFSI; governance (international); governance (national); Global Meat Alliance; government laboratories; His Majesty's Revenue and Customs (HMRC); inspectors institutions; Interpol; laboratories; laboratory services; Laboratory of the Government Chemist (LGC); local government; Marine Stewardship Council; National Reference Laboratories; NFCU; primary authority; procurator fiscal; public analysts; regional regulatory groups; regulator; research bodies; Reading Scientific Services Ltd (RSSL); Safe and Local Supplier Approval (SALSA); standards owner; trade organisations; trading standards; The Stationery Office (TSO); United Kingdom Accreditation Service (UKAS); universities	-
Guardians	Guardianship	ability; accreditation; approval (approval criteria/approved premises); assurance; certification; competitors collaborating;	-
Hurdles	control measure; countermeasures; global countermeasures; specific countermeasures	hard controls: defensive space; infrastructure; site security: biometrics; keypads; thumbprint recognition; video surveillance; soft controls: training; adapting training to audience; education; expertise; past experience; knowledge; staff onboarding;	active controls; formalisation
Hurdles	Mass balance assessment	checks and balances; ingredients; inventory system; invoices; menus; order; packaging control; production records; bill of materials; production list; stock system; sales; stock control; transactions	reality checking
Operationalisation	accountability; capability; communication; competence; complexity; credibility; gaining trust; holistic; leanness; multidimensionality; permeation; reputation; responsibility; sophisticated; transparency; visibility;	business attitude; capable people; capable systems; skillset; process led thinking; structured decisions; integrated management systems; judgement; linear thinking; live systems - real-time detection; management commitment; organisational behaviour; organisational structure; preventative measures; real-time systems; redistribution; siloed thinking; systems thinkers;	accessible; barriers, bias; competitive advantage; embeddedness; farm to fork; fragmentation; non-competitive aspects; product development; speed of response; transactional;
Risk	-	acceptable risk; aggregate risk; biggest risk; external risk; food fraud risk; food fraud risk assessment; high risk; high risk countries; high risk ingredients; internal risk; long term risk; low risk; reputational risk; risk assessment; risk averse; risk awareness; risk matrices; risk minimisation; risk mitigation; risk prioritisation	dynamic; detectability; likelihood; perfect storm; severity; short termism; uncertain
Supply chain	upstream prevention	buying; buying on price; dedicated suppliers; designated suppliers; online sales; packaging; preferential supply chain; reputable source; reputable supplier; supplier assurance programme; supplier delisting; supplier information; supplier questionnaire; contingency suppliers; first tier suppliers; second tier suppliers; spot purchasing; supplier approval; supply base; supply chain relationships; third tier suppliers; trusted suppliers; supply chain mapping; supply chain standards; global supply chains; integrated supply chains; supply chain understanding; supply chain verification;	downstream; export; smaller supply mentality; primary production; import sampling; supply deficit re. supply; supply friction; trade offs; unlevel playing field; value; value proposition;

Regulatory aspects

Name	Importance: Level 1	Importance: Level 2	Importance: Level 3

Official controls (legal)	Compliance; consumer protection; coordination; coordinated intelligence sharing; corroboration; hybridisation; multi-agency collaboration; inspection; integrating food standards; labelling	advice; closure orders; unfair trading; confidence in management; improvement; inspection rituals; derogation;	-
Policing	cautioning; continuity; crime prevention; crime reduction; prosecution; situational awareness	analysts; crime intelligence system; crime reduction officer; four Ps; intelligence apparatus; intelligence officer; interview; Neighbourhood watch; police priorities;	career structure; police;

Appendix 8: What works to prevent food fraud- comparison of food fraud vulnerability assessment models and tools and food fraud prevention strategies

Table 8.1 Food Fraud Vulnerability Assessment Models

Source	Joint Nordic Food Fraud Threat Assessment for Food Fraud	Spink et al. (2016a)	Spink et al. (2019)	Van Ruth et al. (2017)	Silvis et al. (2017)	Yang et al. (2019)	van Ruth and de Pagter-de Witte, (2020)	Song et al. (2021)
Metrics	33 measures 5 x 5 matrix for assessment of impact and probability. 4 x 4 matrix for assessment of impact and probability used in the national threat assessments with the unknown dimension.	5 X 5 Matrix	5 X 5 Matrix	50 measures in radar diagram	50 measures in ribbons SSAFE tool	48 measures (adaption of SSAFE tool) in radar diagrams and ribbons	50 measures with ranking	50 measures in radar diagrams and ribbons
Risk criteria	Impact and probability 5 levels. Very high, high, moderate, low, very low. National threat Impact and probability 4 levels high, moderate, low, unknown	5 levels Very high, high, medium, low, very low	5 levels Very high, high, medium, low, very low	3 levels High, medium, low	-	-	-	-
Likelihood		X	X	-	-	-	-	-
Impact	X Financial X Societal	X	-	-	-	-	-	-
Consequences	-	-	X	-	-	-	-	-
Opportunities	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space	X Technical opportunities; Opportunities in time and space
Motivations	X Financial motives; Culture and conduct	-	-	-	-	X Economic drivers; Culture and behaviour	X Economic drivers; Culture and behaviour	X Economic drivers; Culture and behaviour
Control (supervisory) measures	X Technical; Prevention	-	-	-	-	X Technical measures; Managerial measures	X Technical measures; Managerial measures	X Technical measures; Managerial measures

Table 8.2 Food Fraud Prevention Models

Model	Food Fraud Initial Screening Model (FBO level)	Food Fraud Prevention Strategy (FBO Level)	Food Fraud Prevention Strategy (national level)	Stages of food fraud prevention (FBO level)	Food fraud prevention cycle (FBO level)	HACCP-DP
Source	Spink et al. (2016a)	Spink et al. (2016b)	Spink et al. (2017)	Spink (2019)	Spink et al. (2019)	Wi?niewska (2015); Codex (2020)
Stage 1 Define scope, basic terms and screen hazards/threats	Food Fraud Initial Screening (FFIS) Matrix Variables Product or Group AND Market or Region Step 1 define the scope and basic terms. Step 2 Review incidents (databases) and suspicious activity Step 3A Conduct FFIS for health hazards. Step 3B Conduct FFIS for enterprise wide risks and financial impact.	Food Fraud Initial Screening (FFIS) Matrix Review phase Organise team Create Food Fraud Policy, Mission Statement, Draft Food Fraud Prevention Strategy/Plan Conduct FFIS Gather background information to inform FFVA	Developing a common starting point and the developing and sharing of best practices for vulnerability assessments. Third parties develop standards and protocols so approaches can be audited and certificated.	Gap Analysis – ask seven questions 1. FFVA undertaken (Y/N) 2. FFVA Documented (Y/N) 3. Food Fraud Prevention Strategy Implemented (Y/N) 4. FFPS Documented (Y/N) 5. Annual Food Fraud Incident Review completed (Y/N) 6. All types of Food Fraud addressed (Y/N) 7. All products from both incoming goods and finished goods through to the consumer. Addressed (Y/N) Concept 1. Develop and implement a food fraud policy statement. Concept 2. Create a FFPP Complete seven steps of implementing and managing food fraud prevention. Step 1 Convene a Food Fraud Task Force Step 2 Create an Enterprise-wide Food Fraud Policy/Mission Statement and begin drafting a Food Fraud Prevention Strategy/Plan Step 3. Conduct the pre-filter Food Fraud Initial Screening (FFIS).	Step 1. Consider new information through 1A. Review specific food fraud incidents internally or externally. 1B. Scanning. Consider broad changes for example, market changes. 1C. Public Policy. Consider policy and regulatory changes. Step 2. Fraud Opportunity. 2A Consider guardians and hurdles. 2B. Consider victim. 2C. Consider fraudster. Step 3. Undertake vulnerability assessment. 3A. Initial screening.	Step 1. Assemble HACCP Team and Identify Scope Step 2. Describe product Step 3. Identify intended use and users (especially vulnerable groups) Step 4. Construct flow diagram Step 5. On-site confirmation of flow diagram Step 6 (part). List all potential hazards that are likely to occur.
Stage 2 Conduct hazard analysis/vulnerability assessment and document	Food fraud vulnerability assessment (very high to very low) Step 4 (paper states this is risk ranking)	Undertake FFVA	Undertake FFVA at national and business level	Step 4. Review additional needs including additional information or a more detailed Food Fraud Vulnerability Assessment (FFVA).	Step 3. 3B Undertake a vulnerability assessment. 3B. Detailed vulnerability assessment.	Step 6. (part) Conduct a hazard analysis to identify the significant hazards (Principle 1)
Stage 3 Undertake risk ranking using matrix or decision tree or other tool.	Corporate Risk Map Plots FFIS risk assessments 5x5 matrix likelihood (very high to very low) AND Impact (very high to very low). Step 4 In Spink et al., (2019) this changes to Likelihood and consequences	Map food fraud vulnerabilities	-	Step 5. Review specific food fraud vulnerabilities in an enterprise risk amp (Enterprise Risk Management)	Step 4. Enterprise Risk Rank	Step 6. (part) Conduct a hazard analysis to identify the significant hazards (Principle 1). Often likelihood and severity used.

Model	Food Fraud Initial Screening Model (FBO level)	Food Fraud Prevention Strategy(FBO Level)	Food Fraud Prevention Strategy (national level)	Stages of food fraud prevention (FBO level)	Food fraud prevention cycle (FBO level)	HACCP-DP
Stage 4 Development, validation, implementation and verification of a food control management system (FCMS)	Resource Allocation Decision based on risk rating, (Step 4)	Consider countermeasures and control systems to address Very High and high vulnerabilities. Propose a Food Fraud Prevention Plan.	Develop and implement appropriate countermeasures and control systems.	Step 6. Consider countermeasures and control systems to address the ;very high' and 'high' vulnerabilities. Step 7. Propose a Food Fraud Prevention Strategy including the calibration of the Food Fraud risks on the enterprise risk map.	Step 5. Rank Step 6. Countermeasures and control system. Feedback loop back into Step 1.	Step 6 (part) Consider any measures to control identified hazards (principle 1). Step 7. Determine the Critical Control Points (CCPs) (Principle 2). Step 8. Establish validated critical limits for each CCP (Principle 3). Step 9. Establish a monitoring system for each CCP (Principle 4) Step 10. Establish corrective actions (Principle 5) Step 11. Validation of the HACCP Plan and verification procedures (Principle 6) Step 12. Establish documentation and record keeping (Principle 7) Step x. Training (Codex requirement but not described as a step). Step y. Food defence plan Determine CDPs in your process. Devise food defence mitigations. Step z. Implement, test, assess and maintain the defence mitigations.

Appendix 9: What works to prevent food fraud - chain of custody, mass balance analysis, and guardianship

The International, Social, Environmental, Accreditation and Labelling (ISEAL) Alliance are a non-profit organisation that codify best practice standards for sustainable practice for over 35 standards. They are an example of institutional guardians who have a role in ensuring that fraud relating to the claims on food products does not occur. One focus for the ISEAL Alliance is to promote strong guardianship practices for their members. Among those practices is the chain of custody system.

The **chain of custody (CoC) system** is: 'the list of all organisations (supply chain) that take ownership or control of a product during production, processing, shipping and retail (physically and/or administratively)' (ISEAL Alliance, 2016). The CoC system can either be prescribed by

regulation, market standards, or developed as part of a supplier assurance programme by an individual organisation. A CoC system can be a key element of a FFPS underpinning the FFPPs at FBO or supply chain level. Box 1 includes the elements of a CoC system.

Elements of a Chain of Custody System (adapted from the ISEAL Alliance, 2016) can include:

- Identification of the origin and identity if claims are made of the components of a final product through mass balance assessment.
- Mass balance assessment demonstrates the volume sold (production output) matches or does not exceed the volume expected to be produced from the materials procured.
- Developing a secure, immutable record of the custodial sequence of all components of a final product from supplier through to consumer (this includes not only ingredients, but also packaging, processing aids etc.)
- Developing communication between members of the supply chain so information can be shared.
- Developing procurement assessment protocols so that all business entities have a unique identity which can be verified, including the undertaking of due diligence checks.
- Verification of the chain of custody, for example, through material testing, auditing, checking of certification and other methods as appropriate.

ISEAL differentiate between mass balance analysis verification at batch level, site level, and supply chain level depending on the granularity of the reconciliation undertaken. Interviewees in this study cited activities such as stock checks, reconciliation between invoice and actual deliveries, and checking products purchased with a specific identity for example, organic ingredients versus product sold with the same stated identity (organic product made from the ingredients) as examples of mass balance analysis verification. From the fashion sector, Better Cotton CoC and ISEAL member, is one such example of 'what works' in terms of developing greater supply chain transparency .

Independent mass balance analysis is already a pre-requisite utilised during the verification processes in multiple food supply third party certification schemes such as organic food certification, and the BRC Global Standard. Mass balance analysis, especially digital real-time mass balance analysis increases transparency through transaction data including the types and quantities of products sourced, from where and for what purpose. Public or state verification of such data would give insights into potential anomalies in the CoC for a food product. Regulators and FBOs can increase the level of deterrence for fraudsters, as a prevention measure, by increasing the effort required by perpetrators to commit food fraud by introducing additional requirements to improve supply chain transparency, for example, the adoption of mass balance analysis using both financial and production data. One example of this approach is the Innovate funded The Digital Sandwich project which is seeking to use blockchain-based technology.

Where claims are being made about a product the potential for detection is also a potential deterrence strategy. One quote from the interviews which captures this was:

"… like the Sicilian lemon, you know, if you're a manufacturer and you're strapped for cash. It's that easy. Well, no one's going to really taste the difference. No one's going to notice. It's got the right label on it. It's got the right packaging. … Is it going to taste that different? It's not like you're buying it as lemon. You're probably putting it on a cake or within a seasoning. It's 0.05% not 5% of the product. Are you going to notice the difference?"

Deterrence is also a key theme that has emerged from the literature and the interviews as an essential element of a FFPS at national, but more particularly at FBO levels. We believe that guardians, and in particular guardianship, is a crucial component of deterrence. Guardians monitor and protect food, consumers, FBOs, supply chains, and nations against illegal activity (Cohen and Felson, 1979). Guardianship requires the collaboration of multiple actors to create an

inter-organisational guardianship network, however regulators and enforcement bodies have a specific role in the overarching regulatory protection applied where FBOs are unable to protect themselves or have insufficient information or empowerment to make decisions on their own behalf (Kowalska and Manning, 2022). The range of guardians that the interviewees mentioned in the interviews have been collated in the codebook (Appendix 7).

There is evidence that effective guardianship (regulations, enforcement, and surveillance systems) by regulators, FBOs and food supply chains reduces the likelihood of food fraud incidents occurring (Qian et al., 2020; Kowalska and Manning, 2022). More activities should be undertaken to improve guardianship networks especially to support micro and small FBOs. The sense of powerlessness of micro and small businesses in addressing food fraud, in embedding capable guardianship, was a theme that emerged from the interviews. Concerns were raised too in the interviews in terms of the capacity and capability of guardians within existing systems in the UK and one prevention strategy for the large organisations was to only do business with organisations who could demonstrate their capable guardianship.

Capable guardianship has been considered in Australia with regard to financial fraud (Lindley et., 2012) and is a key requirement within national, supply chain level and FBO level FFPPs. Capable guardians not identified by the interviewees, but still important in terms of national and industry level FFPPs are security guards, staff working at ports and border inspection points. Within the banking sector and with computer systems technology has also formed a guardianship role. Perpetrators will be less likely to commit fraud if there is an increased level of countermeasures or hurdles implemented through capable guardianship and this will act as a deterrent. A Venezuelan study. concluded that auditing as a sole verification activity did not guarantee or improve fraud prevention. Instead FFPPs needed to address:

- Improving the effectiveness of components and procedures of internal control with an anti-fraud basis.
- Clearly defining behaviour that is acceptable and unacceptable (for internal and external parties).
- Integrating all levels of management within the FFPP and food fraud strategies
- Segregation of duties to prevent fraud.
- Periodical reporting on fraud suspicion or fraud practice.

These elements were all echoed in the interviews in our study and exemplar quotes are included in Appendix 5. Some research has suggested that food fraud detection technologies are a form of capable guardian as its presence reduces opportunity and FBO vulnerability and acts as a deterrent because some types of food fraud can be detected (Ellis et al., 2016). Ellis et al. (2016) argue that "future sensor/detection platforms and technologies, along with future predictive computational methods could together take on the capable guardian role, and assist in significantly reducing the areas of vulnerability to fraud within food supply chains." We would echo that statement.