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# Food fraud: policy and food chain

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Food supply chain fraud can arise in terms of the integrity of the food item, the processes used to produce that food item and/or the people employed and the data that accompanies the food item. Emergent food fraud themes include characterization of food fraud, drivers of supply chain fraud, traceability systems and mechanisms for deterrence. Options for action at global, supply chain and organizational levels are the ongoing development of data centralization systems especially ensuring that distinct databases can be coordinated to add value through collective data analysis, and secondly ensuring there are appropriate deterrence mechanisms in place so that food fraud mitigation moves from a stance of fraud detection to one of fraud prevention.

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## Introduction

The Grocery Manufacturers Association estimates that global food fraud costs between $10 billion and $15 billion per year, affecting approximately 10% of all commercially sold food products [1]. Fraud can be described as the intentional misrepresentation of fact by one person solely, or acting on behalf of an organization, in order to encourage another individual erroneously to part with something of intrinsic value. Fraud in the food supply chain can arise as a result of misrepresentation associated with (1) product integrity (authenticity) — the inherent quality attribute of totality or completeness [2] that is intrinsic characteristics; (2) process integrity — the activities undertaken to produce the food item encompassing the design, assurance, monitoring and verification of processes within the product life-cycle to ensure that they remain authentic and intact, that is extrinsic characteristics; (3) people integrity can be described as the honesty and morals exhibited by an individual and/or (4) data integrity of information accompanying the food item throughout the supply chain that is the consistency and accuracy of data through the food product life-cycle (Table 1). In this regard, the concept of food integrity as having four elements is considered as novel. The aim of this paper is to review current literature in the area of product integrity with emphasis on food fraud and potential options for action to mitigate food integrity risk. The paper will firstly differentiate between and define the elements of food integrity, secondly explore the characteristics of food fraud, then the drivers of food fraud and the potential for mitigation.

Fraud risk increases when controls, or specific measures, that have been put in place to ensure food integrity do not operate as intended by management. Fraud erodes consumer trust and has the potential, dependent on the nature of the fraud, to harm human health [1,3–5,6•].

## Categorizations of food fraud

Analysis of the fraud notifications in the European Union (EU) Rapid Alert System for Food and Feed (RASFF) led to the determination of six fraud categorizations (Table 2). False, improper or missing labels/documents are most common type of food fraud reported in RASFF and in terms of frequency of fraud incidents, products of animal origin (POAO) dominate as well as food supplements [7•]. However, it should be noted that the use of purposive sampling toward POAO at points of entry into the EU, and focus on particular products as a result of a history of non-compliance may influence this finding. Thus it can be postulated that products not sampled through regulatory or random processes may still be subject to an equivalent incidence of as yet unrecognized food fraud. Seven types of food fraud have been proposed: adulteration, counterfeit product, diversion of products outside of intended markets, over-run, simulation, tampering and theft [8,9]. An adulterant can be deemed to be any poisonous or deleterious substance [10,11••] and some adulteration is economically motivated [12]. Food fraud is multifaceted and by nature complex. In order to avoid detection such criminal activity is covert, entrepreneurial and opportunist, making the development of risk mitigation strategies at organizational, supply chain and global levels difficult. There are multiple drivers of supply chain fraud and assumptions are often made as to the likelihood of occurrence and severity of a potential issue, where there is often no underpinning evidence to support either the degree of fraud risk or the given course of mitigating action.

**Table 1**

**Elements of food integrity.**

| Elements of food integrity | Examples |
|---|---|
| Product integrity | Adulteration and economically motivated adulteration (EMA), counterfeit product, expiration date, simulation, tampering |
| Process integrity | Diversion of products outside of intended markets, illegal importation, over-run, theft |
| People integrity | Characterizations such as the cyber criminals and hacktivist, disgruntled individual, extortionist, extremist, irrational individual, opportunist, professional criminal |
| Data integrity | Illegal importation, improper, fraudulent, missing or absent health certificates, improper, expired, fraudulent or missing common entry documents or import declarations; mislabeling |

Adapted from Bouzembrak and Marvin [6•], PAS 96 [4], and Spink and Moyer [8,9].

## Drivers of supply chain fraud

Supply chain fraud is driven by market competition often with organizations that have better economies of scale or operate as oligopolies [13••]. The lack of sanctions and the low probability of discovery make food fraud a significant and growing problem [14]. Some argue malicious intent is weakly addressed by EU food safety law [15], whilst others propose that food safety law is of limited value in regulating food fraud as food safety is concerned with unintentional food contamination whilst food fraud encompasses activities associated with the intent to mislead [11••]. Local and niche foods are not immune to fraud, and there is an increasing requirement to demonstrate product and process authenticity [16,17]. Alternatively, complex food supply chains, involving multiple national or regulatory boundaries makes fraud harder to trace especially where food commodities change hands a number of times on paper, if not actually physically [13••]. In addition to complexity, lack of visibility, and lack of trust, there is data swamping of retailers, food businesses and their employees, when due to a push for 'leanness' these organizations are often time poor, and in an environment of weak supply chain governance, these can in consort lead to what is often opportunistic, fraudulent behavior [18,19]. Sub-contracting physical production of food products can present a risk to the brand owner and ultimately the general public too. Supply chain factors that will mitigate fraud include: appropriate legislation, technology, inventory management procedures, focused procurement practices and effective relationship management [19]. Therefore, food fraud risk is situational and characterized by the wider environment in which the food trade or food operation takes place. Each of the four elements of food integrity are now considered.

**Table 2**

**Example food fraud categorizations.**

| RASFF food fraud categorizations Bouzembrak and Marvin [6•] | Spink and Moyer [8] |
|---|---|
| • Improper, fraudulent, missing or absent health certificates; | • Adulteration, • Counterfeit product, |
| • Illegal importation; | • Diversion of products outside of intended markets, |
| • Tampering; | • Over-run, |
| • Improper, expired, fraudulent or missing common entry documents or import declarations; | • Simulation, |
| • Expiration date, and | • Tampering and |
| • Mislabeling. | • Theft |

## Product integrity fraud

In the literature, there are multiple examples of product fraud including: cereals [20], dairy products [21], fish [22–28], high value fruits and fruit juice [1,29], meat especially exotic and bush meats, for example macaque monkey meat sold as bush meat, meatballs or in soup products in Indonesia [30–33], nuts, (which is of concern if substitution involves allergenic materials for example peanuts being substituted for almond) [34], potato genotype mislabeling [35], spices such as saffron [36–40], and honey, organic foods, coffee and so forth [1]. Rapid and reliable sensor, spectroscopic and chromatographic techniques have recently emerged, and combined with the use of multivariate and multi-way chemometrics, if the tests have been developed and validated, product integrity can be verified. Product verification is often involves high product testing costs, and sometimes inappropriate sample turnover times do not support a just-in-time driven food supply system. The cost of product integrity testing and the lack of appropriate nondestructive tests means that verification of process integrity rather than product integrity is more usually undertaken by the food supply chain [14,41].

## Process integrity fraud

Aung and Chang argue that current food labeling systems cannot guarantee that food is either authentic, of good quality or safe [42]. Extrinsic process characteristics such as methods of production, vegetarian or vegan products, labor and animal welfare standards, compliance with assurance standards, country of origin or geographic location, are often used as 'value descriptors' rather than the innate, intrinsic characteristics of the food itself. This means that such products are vulnerable to process integrity fraud. Fraud can occur in many chains including mislabeling of organic product [43,44]. Origin fraud has

been identified at different levels including incorrect identification of geographic origin, by country or region. Geographic traceability to a location, country or region is often verified through isotope analysis for example protected designation of origin (PDO) olive oil [45,46], wine traceability to a specific vineyard [47,48], using NMR fingerprinting to identify the country or region of origin of coffee or wheat [49–51]. Bio-informatic analysis and the use of DNA markers could provide a rapid tracing tool for identifying animal origin adulterants in vegetarian food [52] and such techniques have wider application. By using non-targeted spectrometric or spectroscopic chemical analysis followed by multivariate statistical evaluation of data, food can be distinguished in terms of geographical origin, species, variety or potential adulteration [53]. However, whilst multivariate screening methods are increasingly being implemented for different food products there is no worldwide, harmonized criterion for their validation and this vulnerability affects the success of such measures being universally adopted to address food fraud [54]. This area of food fraud is of concern where provenance is an integral contributor to the value of a given food, such as olive oil, champagne etc. fingerprinting, mapping and other forms of characterization are currently being put in place as a measure to mitigate food fraud.

## Data integrity fraud

Four types of traceability systems have been suggested as being that value: 'book and claim' (certificate based integrity system), identity preservation (track and trace based integrity system), segregation (separation based integrity system) and mass-balance (volume based integrity system) [55]. Often, traceability systems are challenged by either, the inability to link documentation and/or data across the food chain; the inaccuracy of, and errors in, documentation; and delays in being able to access essential data [56]. Traceability can only be delivered if there is interoperability between management information systems [57] demonstrating that an efficient traceability systems needs to plan, develop and implement multiple techniques in an integrated product and process monitoring system [58]. The authors differentiate between two types of traceability:

- Logistics traceability — tracking and tracing and logging the physical movement of the product (quantity, origin, destination, dispatch date) and
- Qualitative traceability that links additional information to the product for example pre-harvest and post-harvest techniques, storage and distribution conditions [57,58].

In order to ensure instant access to information, traceability and centralization of the data that verifies product and process integrity criteria will become standard practice. This approach will be enabled though technical advancements in information management systems and real-time technology such as radio frequency identification (RFID), innovative use of smartphone technology or packaging features such as special inks, or holograms on cases of product or on each pallet [59,60•]. Options for action at global, supply chain and organizational levels in the ongoing development of data centralization systems include ensuring that distinct databases can be coordinated to add value through collective data analysis. In consort, there must be appropriate deterrence mechanisms in place so that food fraud mitigation moves from a stance of fraud detection to one of fraud prevention.

## Personal integrity fraud

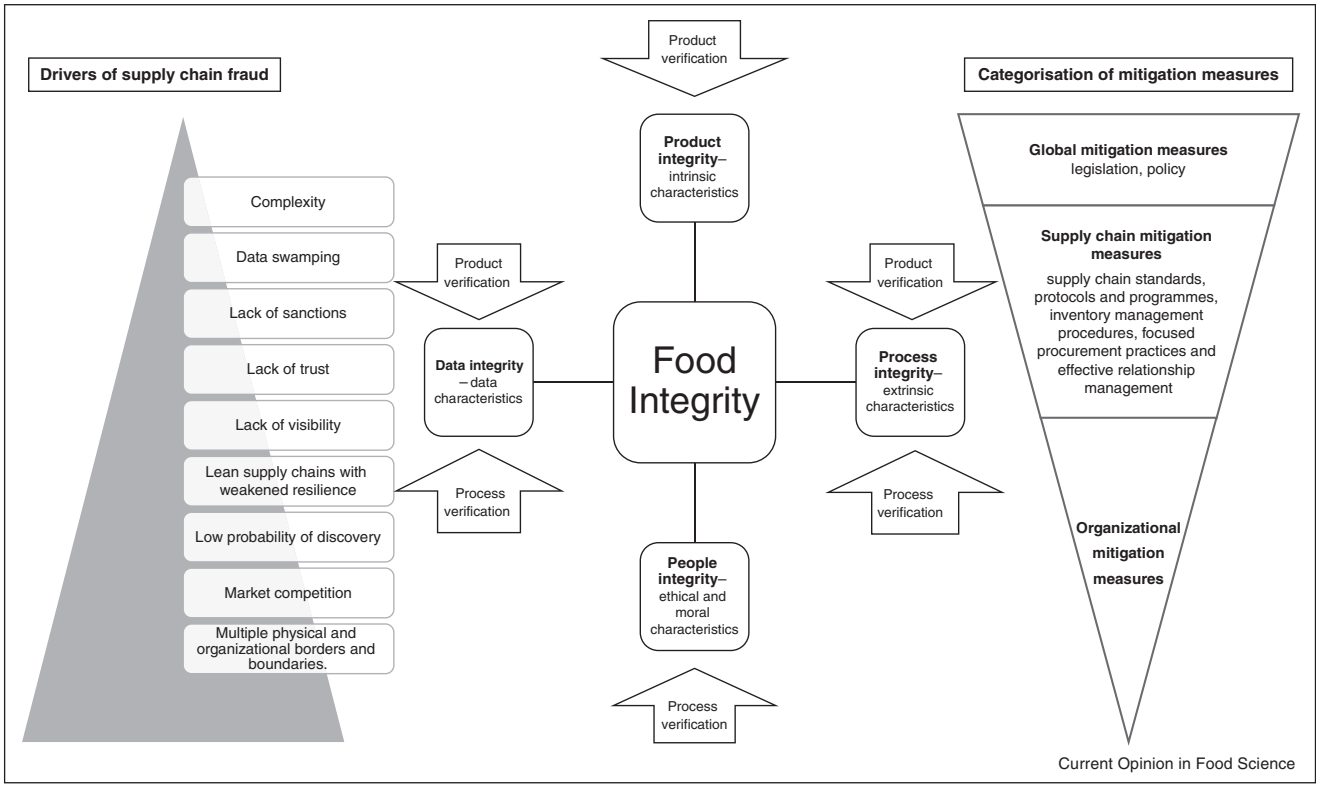
Deterrence can be described as the inhibition of perpetrator activity as a result of concern over the personal consequences to themselves as a result of taking an action or the maintenance of appropriate preventive measures, or countermeasures that will discourage their activity. Threat analysis critical control point (TACCP) uses an assessment approach to identify the likelihood of an incident occurring and how it might be mitigated through the use of appropriate countermeasures [1]. Countermeasures are intended to reduce criminal opportunity so if appropriate countermeasure strategies are to be developed then it is important to establish both the type of fraud and the typology of the fraudster [5,13••,60•,61••]. Appropriate process verification measures such as audits need to be in place to ensure security measures, personnel procedures and other countermeasures are adopted, and effective.

## Discussion

As has been addressed in this paper, food fraud can arise in terms of the intrinsic integrity of the food item, the extrinsic processes used to produce that food item and/or the people employed to produce the food and the data that accompanies the food item. The drivers of food fraud explored in the paper and include data swamping, lack of sanctions, lack of trust and visibility, low probability of discovery, market competition and complexity in terms of the chain and the boundaries and borders that food passes across. The elements of food integrity have been defined and differentiated both in terms of the nature of the associated fraudulent activity, measures to mitigate risk and the methods for testing and verifying the food items. A model of food integrity management and mitigation is developed (Figure 1).

The model has three key constructs (a) food integrity is characterized as four elements: product integrity, process integrity, people integrity and data integrity, (b) drivers of supply chain of food fraud are described, and (c) example mitigation measures are differentiated as operating at three levels: organizational, supply chain and global measures.

**Figure 1**




Food integrity management and mitigation model.

## Conclusion

Food fraud is a concern for all food businesses. Food integrity is central to the intrinsic and extrinsic characteristics of the product and underpins the value associated with the food item. Food fraud mitigation strategies are being developed at organizational, supply chain and global levels in order to minimize what is a situational product focused risk. These strategies must be adaptive and respond to the impact of market environments and other potential risk factors.

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- • of special interest
- •• of outstanding interest


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