

Fraud in Food Products

Fraude em Produtos Alimentícios

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Abstract

In the context of food quality, Food Fraud has been identified as an emerging risk for the food industry and a significant concern for consumers and official supervisory bodies. Fraud refers to changes in a food product, always for profit, disrespecting the consumer's right in addition to representing a risk to human health. These frauds have the ability to diminish consumer confidence in their food supply and interfere with the reputation of honest food business operators. Thus, this review aimed to point out the opportunities for fraud and adulteration in some foods, showing the different ways of carrying them out, and also, some cases that have

occurred throughout history. While pointing out the need for investment in specific and effective analyzes of production processes by the industries, in addition to control measures, actions aimed at reducing or eliminating possible hazards, which contributed to ensuring the quality and safety of products.

Keywords: Industrialized food; Production chain; Adulteration.

Resumo

No contexto da qualidade dos alimentos, a Food Fraude vem sendo identificada como um risco emergente para a indústria alimentícia e uma preocupação expressiva dos consumidores e órgãos oficiais de fiscalização . A Fraude se refere a modificações em um produto alimentício, sempre com fins lucrativos desrespeitando o direito do consumidor além de representar um risco a saúde humana. Essas fraudes tem a capacidade de diminuir a confiança dos consumidores em seu suprimento de alimentos além de interferir na reputação dos operadores honestos das empresas alimentícias. Dessa forma, essa revisão objetivou pontuar as oportunidades de fraude e adulteração em alguns alimentos, mostrando as diversas formas de realização, e também, alguns casos transcorridos ao longo da história. Sem deixar de assinalar a necessidade de investimento em análises específicas e eficazes nos processos produtivos, por parte das indústrias, além de medidas de controle, ações com o objetivo de reduzir ou eliminar possíveis perigos, que contribuía para assegurar a qualidade e segurança dos produtos.

Palavras-chave: Alimentos industrializados; Cadeia produtiva; Adulteração.

Resumen

En el contexto de la calidad de los alimentos, el fraude alimentario se ha identificado como un riesgo emergente para la industria alimentaria y una preocupación importante para los consumidores y los órganos de supervisión oficiales. El fraude se refiere a cambios en un producto alimenticio, siempre con fines de lucro, irrespetando el derecho del consumidor además de representar un riesgo para la salud humana. Estos fraudes tienen la capacidad de disminuir la confianza del consumidor en su suministro de alimentos e interferir con la reputación de los operadores de empresas alimentarias honestos. Así, esta revisión tuvo como objetivo señalar las oportunidades de fraude y adulteración en algunos alimentos, mostrando las diferentes formas de llevarlos a cabo, y también, algunos casos que se han producido a lo largo de la historia. Al tiempo que señala la necesidad de invertir en análisis específicos y efectivos de los procesos productivos por parte de las industrias, además de medidas de

control, acciones encaminadas a reducir o eliminar posibles peligros, que contribuyan a asegurar la calidad e inocuidad de los productos.

Palabras clave: Alimentos industrializados; Cadena productiva; Adulteración.

1. Introduction

The United Nations in 2019, estimates that the world population will grow by 2 billion people in the next 30 years, going from the current 7.7 billion individuals to 9.7 billion in 2050 (United Nations Brazil, 2019). All this global concentration requires water and food for the survival of humanity, which still requires energy, inputs, and basic sanitation to maintain its contemporary habits (Santos et al., 2020). As the global population continues to grow, much more effort and innovation will be needed to sustainably increase agricultural production, improve the global supply chain, decrease food losses and waste, ensuring that all who suffer from hunger and malnutrition, have access to adequate food (United Nations, 2020).

The intake of essential nutrients provided by food is essential for good health. As well as the specific foods that provide nutrients, the countless possible combinations between them and their ways of preparing, the characteristics of the way of eating and the social and cultural dimensions of eating practices (Ministério da Saúde, 2014). In addition to adequate calorie consumption and balanced nutrition, the availability of micronutrients is relevant when referring to healthy eating practices. Unhealthy diets and lifestyles may be closely linked to the increasing incidence of non-communicable diseases in developed and developing countries, such as obesity (United Nations, 2020).

Brazil is one of the world's largest food producers. According to the World Trade Organization, it is the third-largest exporter of agricultural products, behind only the European Union and the United States. The abundance of sun, water, and land in Brazil creates agricultural conditions that are not only sustainable but also prepared to meet the growing demand for food on the planet. It is estimated that within 35 years Brazil will be responsible for producing 40% of the food that will be consumed by a world population of nine billion people (Tibola et al., 2018). Mitigating world hunger, achieving national sovereignty, coupled with the promotion of sustainable agriculture, is the great challenge for Brazilian agriculture.

In this context of food quality, food fraud has been identified as an emerging risk for the food production and a significant concern for consumers and official supervisory bodies.

It is estimated that 10% of food products could contain a fraudulent component (Barrere et al., 2020). These frauds have the ability to diminish the confidence that consumers have in their food supply and have serious inferences for the reputation of honest food business operators (Ulberth, 2020). Not to mention the health risk that this criminal practice can cause in public health.

In Brazil, opportunities for food deception and adulteration are frequent due to a large amount of food produced, exported, and imported, these frauds, despite being predicted as crimes, occur because they are very profitable. Geographic regions with high susceptibility to food deception and adulteration are often developing areas with political and social instability and a large and growing population. Brazil meets many of these conditions and, therefore, is subject to attempts at food scam and adulteration (Tibola et al., 2018).

The prospect of profitability, even at the hazard of legal sanctions, encourages this dishonest practice, putting consumers' physical integrity at risk and aggravating the health system. Thus, this review aimed to point out the opportunities for fraud and adulteration in some foods, showing the different ways of carrying them out, and also, some cases that have occurred throughout history. While pointing out the need for investment in specific and effective analyzes of production processes by the industries, in addition to control measures, actions aimed at reducing or eliminating possible hazards, which contributed to ensuring the quality and safety of products.

2. Methodology

The methodology used to carry out this scientific article was the bibliographic research methodology. It is grounded on the investigation of theoretical material on the subject of interest. This methodology has a qualitative character, that is, it is the study of an object, Food Fraud, seeking to interpret it in terms of its meaning. In this sense, the analysis considers subjectivity more. The objective is to consider the totality and not data or isolated aspects (Alyrio, 2009). The researcher is the main instrument, the data collected are preferably descriptive, the analysis of data and information tends to follow an inductive process (Pereira et al., 2018).

3. Bibliographic Review

3.1 Food Fraude

It is accepted that food fraud is well-defined as an illegal mistake to obtain economic gains through food (Lord et al., 2017). Fraud is the term that applies to any practice that is not universally accepted, to be applied without the consent of official regulatory bodies, leading to changes in an edible product, always for profit disrespecting consumer rights (Kolicheski, 1994). Food fraud - including the economically motivated subcategory of adulteration - is an urgent global public policy issue that requires the progress of common definitions and harmonized prevention management systems (Spink et al., 2019). The same can be done throughout the supply network, by suppliers, food manufacturers, retailers, and importers. A holistic perspective of food fraud includes adulteration, theft, diversion, unauthorized production, and counterfeiting (Kowalska, 2018).

Food can be considered adulterated if it contains any foreign substance; when a substance has been removed beyond the tolerance limit, without the consumer being properly informed on the product label; any component was omitted or any color, preservative, or substance not permitted by the current health legislation was added (Brasil, 2004). It is significant to point out that, practically, all food products can be subject to fraud by substitution, dilution, forgery, diversion, improvement, or incorrect identification. Food scam can represent a real risk to public health and can have serious impacts on consumers and the industry in cases that cause illness or death (Barrere et al., 2020). As possible damage to health caused by the ingestion of undeclared constituents in individuals with medical or nutritional restrictions, such as allergies and intolerance to certain components (Carvalho et al., 2015).

In Brazil, the Consumer Protection Code (CPC) states that: “They are unsuitable for use and consumption: Products whose expiration dates have expired; products that are deteriorated, altered, adulterated, damaged, falsified, corrupted, fraudulent, harmful to life or health, dangerous or, still, those that do not comply with the regulatory norms of manufacture, distribution or presentation; products that, for whatever reason, prove to be unsuitable for the purpose for which they are intended (Brasil, 1990). According to the Penal Code, article 272: “Corrupt, adulterate, falsify or alter a substance or food product intended for consumption, making it harmful to health or reducing its nutritional value, the offender is subject to a prison sentence of 4 (four) to 8 (eight) years and a fine” (Brasil, 1940).

The RIISPOA (Regulation of Industrial and Sanitary Inspection of Products of Animal Origin) considers food products as adulterated when altered or impure raw materials, different and or containing materials of different species, have been used in the composition of standard foods without prior authorization inspection department for products of animal origin and without the constant changes in product labels. It is worth mentioning that adulteration can also be related to the replacement of high-cost components with others of less economic value (Silva et al., 1999).

Food supply network are increasingly vulnerable to swindle as a result of globalization, trade liberalization, inconsistent food laws in countries and regions, inadequate legislation, the powerless functioning of public food control institutions, long and complex food supply chains, growing anonymity of the people who run food companies on the Internet, pressure from the market to reduce food prices, the scientific and technological progress that are available to society and the malicious fraudsters take ownership of these technological resources with a view to the prospect of high profitability (Kowalska, 2018). Inadequate and incomplete regulation ensured an environment conducive to the production and marketing of counterfeit and non-authentic food products on the market, with negative health effects such as allergies, cancer, intolerance. In the economy, tax evasion, and unfair competition (Borma, 2018).

Unfair competition leads to market distortions, which in turn can affect the local economy or the international economy. The full extent of the problem is unknown; this is because those who commit food fraud wish to evade detection, many fraudulent activities go unnoticed and are not recorded in official reports (Ulberth, 2020). The realization of food scam is also made possible by the difficulty of consumers in determining information about the nature of food, even after purchase. Furthermore, this information is usually asymmetric; although producers know whether a product is of high quality or not, certain attributes of the product are not detectable by consumers through research or experience (Zilberman et al., 2018; Meerza et al., 2019).

An authentic finished food product must also comply with the labeling regulations, mainly in terms of the composition of ingredients, protocols and production practices, technology, and genetic identity. Food product authentication is the procedure by which it is verified that the product corresponds to the instructions on the label and if it complies with the established regulations (Kowalska, 2018). Resolution RDC 259 states that all labels must have understandable and clear information and must not mislead the consumer as to the real benefits and risks. Among the information that the label must contain, there is a description of

the list of ingredients; origin identification; name or corporate name and address of the importer, to provide subsidies to track fraudsters (Brasil, 2002).

In industries, technical regulations for identity and product quality are required, ensuring product integrity and safety. In food production, Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP) programs, Threat Analysis and Critical Control Point (TACCP) and Vulnerability Analysis and Critical Control Point (VACCP) programs are employed. These tools are related to the food safety management system, where the unusual point is the adulteration preventive measures (unintentional, accidental, or intentional) recommended in the entire production chain by Organs inspection agencies, for example, the National Health Surveillance Agency (ANVISA) and Ministry of Agriculture, Livestock and Supply (MAPA) (Figueira, 2018).

3.2 Fraud in Meat Products

The driving force of food adulteration is to enhance recipes using a cheap ingredient to replace a more expensive one or, partially, to remove the most valuable component in the hope that the altered product will go unnoticed by the end consumer (Ulberth, 2020). During the consumption of meat products, consumers evaluate quality indicators through extrinsic (brand, price, and packaging) and intrinsic (physical characteristics) attributes. However, consumers do not have the ability to confirm the magnitude of safety of these products before purchasing them, because the evaluation of meat quality is a credibility attribute (Quevedo-Silva et al., 2019). The adulteration of meat products can be practiced by the partial or total substitution by the meat of species of low commercial value. The motivation is mainly economic, which can affect the health of individuals and communities, causing an economic impact on public health, if meat with low allergenic potential is replaced by meat with high allergenic potential (Carvalho et al., 2015).

The substitution of horse meat in beef products is a global health problem. In 2013, a 2-month investigation into the legitimacy of beef products culminated in the publication of results that demonstrated the incidence of horse meat in a frozen hamburger produced in Ireland (Wiedemair et al., 2018). The DNA tests were achieved by the Irish Food Safety Authority. They confirmed the occurrence of up to 29% of horse DNA. It was a complex case of food fraud involving several producers and suppliers across Europe (Kailemia, 2016). Although the consumption of horse meat does not have a direct problem of food security, the

scandal revealed a break in the traceability of the food chain, also perceived by consumers (Di Giuseppe et al., 2015).

There is also the occurrence of commercial fraud by substituting beef for buffalo meat. There are several factors that contribute to the occurrence of adulteration, the low value of buffalo meat is a factor of choice. The low added value is due to the lack of adequate legislation for buffalo production in the nation. As a result, animals are slaughtered and sold like cattle in many locations. Another issue is the similarities in characteristics such as color, aroma, flavor, and texture between beef and buffalo meat, in addition to the identical commercial cuts between these animals, making it difficult for consumers to find the difference between products at the time of purchase. In addition, although Brazil has a tracking system (SISBOV), it has many limitations in its application due to geographic diversity (Dantas et al., 2019).

In Brazil, the operation “Carne Fraca” promoted by the Federal Police (FP) in 2017, revealed a scheme of adulterated beef and chicken, originating from several companies. The investigation brought to light evidence of the improper use of harmful substances in food production and thus proved adulteration of food products. The FP investigation revealed laboratory fraud at the Brazilian Meat Inspection Service of the Ministry of Agriculture and Supply, revealing evidence of a network of corruption that led to irregularities committed by prominent slaughterhouses in Brazil. This practice compromised product quality and eroded consumer confidence, both domestically and abroad. Causing great repercussion and commotion in the Brazilian population. The image of national brands and companies was damaged, which affected the perception of both importers and local consumers (Quevedo-Silva et al., 2019).

There are some recommended techniques for the identification of food frauds, vibrational spectroscopy is a technological option, it covers the three sister technologies medium infrared (MIR), near-infrared (NIR), and Raman, all allowing for quick and non-invasive analyzes. Raman is the technique most often used in meat analysis due to its multiple spectral information, even in comparison with MIR and Raman, which also makes the further treatment of spectra applying multivariate approaches indispensable (Wiedemair et al., 2018). Another technique under study and indicated for the identification of food fraud is the polymerase chain reaction (PCR), which stands out for its speed and efficiency. This method is considered very promising because it is highly sensitive since minimal amounts of DNA can be detected by species-specific primers (Dantas et al., 2019).

3.3 Fraud in Dairy Products

The regulations for the industrial and sanitary inspection of products of animal origin, consider the occurrence of fraud in milk when there is a replacement of its characteristic components with other aggregates. Including the addition of substances of any nature to hide changes; or any deficiency in the quality of the raw material; any defect in the elaboration; or an rise in the volume/weight ratio of the product (Brasil, 2017). Among the main fraudulent foods, milk contributed 14% of all academic records from 1980 to 2010; second, behind only olive oil (Handford et al., 2016).

The main substances used to defraud milk include water, constituents such as sugar, flour, and whey; as preservatives, chlorine, hypochlorite, hydrogen peroxide or formaldehyde; and neutralizing agents: sodium hydroxide (Condé et al., 2020). To diluted milk, adulterants such as skimmed milk powder, reconstituted milk, urea, rice flour, salt, starch, glucose, vegetable oil, animal fat, melamine, and powdered whey can be added to increase the thickness and viscosity of the milk, maintaining the percentage of fat, carbohydrate and protein composition (Handford et al., 2016).

Some chemicals such as sodium bicarbonate, sodium carbonate, calcium hydroxide, sodium hydroxide, or chemical formalin are added to increase the shelf life. Milk is a perishable product, being possible to be damaged during the transport process, especially in the summer months, if the refrigeration is not adequate (Afzal et al., 2011). Most milk adulterations affect not only quality but also its nutritional value. The added substances can also be harmful and endanger the health of customers (Moraes et al., 2017).

In 2008, the Chinese government announced that a large amount of the country's infant formula supply was contaminated with melamine. Approximately 300,000 babies were affected and at the minimum six babies died. After the melamine scandal, the State General Administration for Quality Supervision, Inspection, and Quarantine re-inspected 1,548 dairy companies and revealed that perhaps as many as 372 milk collection stations had been adding melamine to milk since April 2005. The agency tested 491 different batches of formula from 109 different companies and found that 22 companies, including government-sanctioned "National Chinese Brands", were manufacturing and selling products contaminated with the substance. Almost 20% of all infant formulas available in China were toxic to babies. The scandal made it clear that there were major regulatory problems across the Chinese dairy industry (Ghazi-Tehrani & Pontell, 2015).

One of the oldest and simplest forms of milk fraud occurs by adding variable volumes of water, artificially increasing its volume for greater profit. This addition leads to decreased nutritional value, and if the water is contaminated, there is a risk to human health due to potential waterborne diseases (Handford et al., 2016). Also, it alters the composition and reduces the frothy appearance, density, and nutritional value of milk. This type of fraud is often accompanied by the addition of other substances to replenish density. Adulteration of milk by adding water reduces industrial performance and causes significant economic losses for the industry (Moraes et al., 2017). Detergents are also added to upgrade the cosmetic nature of milk, as the frothy appearance diminishes when it is diluted with water. Calcium thioglycolate, potassium thioglycolate, or calcium salts of thioglycolic acid have already been added to provide milky color and give it a genuine appearance (Soomro et al., 2014).

Another fraud is the addition of whey, this adulteration is among the most committed frauds in Brazil, as this component is 90% cheaper than milk. The common range of fraud is up to 20 or 25% whey added, as the consumer does not notice a difference in taste, but fraud can reach 60%. Brazilian law states that whey cannot be added to milk. However, due to the availability and low cost of whey, this fraud is economically attractive, harming consumers and law-abiding competitors (Mendes et al., 2016). Although the legislation requires daily tests for these substances, the evaluation of milk in the industry is routinely carried out using only physical-chemical analyzes, such as density and freezing point. And frauds are planned to avoid/circumvent identification by non-specific analyzes (Condé et al., 2020).

A major fraud in animal products is the adulteration of dairy products by adding cow's milk to milk obtained from other species, such as sheep, goats, and buffaloes. As the cattle herd in Brazil is larger than the herd of these alternative species, milk production per animal in the latter is less and has seasonal variations, in addition to higher costs than cow's milk. Thus, this fraudulent practice can harm consumer rights, both because of the economic aspect and the danger of consuming milk, which is not stated on the label. In addition, it is salient to determine the kind of milk and the animal species used in the construction of cheese to guarantee the authenticity of the finished product (Carvalho et al., 2015).

In Brazil, cases of milk fraud have been raising awareness in the productive and consumer sectors. As a result, the Public Ministry and the Ministry of Agriculture of Brazil, in 2013, created an operation called "Compensated Milk". In this operation, important frauds were discovered, which betrayed fraudsters from all links in the milk production chain. The most common types of fraud were adulterations - the addition of illegal products such as water and urea to increase the quantity of milk, in addition to caustic soda, hydrogen

peroxide, and lime to reuse spoiled milk and/or prolong the life of milk in the shelves in the market, reducing bacterial multiplication (Breitenbach et al., 2018).

Several targeted analytical methods have been settled to identify specific strange properties in milk; these include high-performance liquid chromatography with single-channel UV absorbance detection (HPLC-UV) and size exclusion chromatography and HPLC-mass spectrometry (HPLC-MS) (Handford et al., 2016). Four main forms of analytical techniques, namely chromatographic, immunological, spectroscopic, and electrophoretic methods, have been developed to identify the animal origin of milk and dairy products. Although DNA and protein-based methods are more sensitive and reliable, they have certain disadvantages: they are unsuitable for complex matrices, less sensitive in heat-treated materials, and require specialists, extraction steps, and specific chemicals for analysis (Sezer et al., 2018). The technological tools available need to be constantly improved to prevent criminal practices, focusing only on profits at the expense of consumers' health.

3.4 Fraud in Extra Virgin Olive Oil

Brazil is among the largest consumers of olive products in the world, importing about 60% of the volume consumed (Silveira et al., 2017). Extra virgin olive oil is rich in monounsaturated fatty acids, mainly oleic acid that differentiates it from other polyunsaturated vegetable oils. Helps maintain good cholesterol levels, while reducing bad cholesterol. In addition to a balanced proportion of saturated and unsaturated fatty acids, it also contains antioxidants that play a role against cancer and other chronic diseases (Ali et al., 2018).

Olive oil is very popular worldwide due to its recognized nutritional and health benefits. Adulteration, fraud, and incorrect labeling of olive oil have become a worldwide phenomenon that leads to decreased consumer confidence (Harzalli et al, 2018). The fraud consists in the addition of other oils of less commercial value, among them are vegetable or animal oils, lampante oil, partially hydrogenated oils that do not have the same functional property as olive oil. The normative instruction n° 1 of MAPA (Ministry of Agriculture, Livestock and Supply) establishes the technical regulation for olive oil and olive pomace oil, determining that lampante oil cannot be destined for human consumption, it is extracted from deteriorated olives and fermented giving a strong smell in addition to high acidity (Brasil, 2012).

In 1981, Spain suffered a massive poisoning that affected more than 20,000 people, leading to the death of more than 300 people, shortly after the start, as a result of the toxic oil syndrome, which was attributed to the fraudulent commercialization of rapeseed oil, originally produced for industrial use and not for human consumption, but sold and labeled as olive oil (Torreblanca-Zanca et al., 2019). In Morocco, olive oil was adulterated with lubricating oil used in jet engines, which made 10,000 people sick. These incidents of fraud with olive oil resulted in risks and uncontrolled public health (Yan et al., 2020).

The classification of the quality of olive oil as extra-virgin, virgin, or lampante oil is regulated by the Commission of the European Union (EU No 61/2011, 2011, EU No 1348/2013, 2013). These regulations take into account the legal levels defined for physical-chemical parameters (for example, free acidity, peroxide value, UV extinction coefficients, and content of alkyl esters), as well as for positive and negative sensory sensations, such as perception and the intensity of the fruit, a positive attribute and the presence/absence of sensory defects: sooty, moldy, rancid and acidified (Harzalli et al., 2018).

Different methods, including medium infrared (IR) spectroscopy, high-pressure liquid chromatography (HPLC), capillary electrophoresis coupled with laser-induced fluorescence, and mass spectroscopy, have been applied to check the oxidative stability and adulteration of extra virgin olive oil with fewer oils expensive. The restriction in its applicability is due to the cost and consumption of time for sample preparation. Nuclear magnetic resonance (NMR), near-infrared (NIR) spectroscopy, Fourier transform infrared spectroscopy (FT-IR), Raman spectroscopy, fluorescence spectroscopy, and synchronous fluorescence techniques have also been used concerning different studies on olive oil of extra virgin olive (Ali et al., 2018).

3.5 Herbs and Spices Fraud

The global herb and seasoning market were valued at \$ 4 billion over 10 years ago and continues to expand. This increase must be related to the increase in meals prepared in highly developed countries, where time restrictions are a relevant factor in daily life (Oliveira et al., 2019). Scandals and food fraud issues in recent years have reinforced the need to understand vulnerability to fraud in food chains. The spice industry is mentioned as one of the most vulnerable, in addition to the meat, fish, and olive oil industries (Silvis et al., 2017).

The world market for spices and herbs is led by Asia with 81% of global production, followed by Africa with 12%, Latin America, and the Caribbean with 3.7%, and Europe with only 2%. However, Europe still leads the technology in the spicing process, generating

products with greater added value, which are exported to several countries in the world (CBI, 2015). The herb and spice sector, which represents a large global industry, is under constant threat from fraudsters. Adulteration of valuable condiments such as saffron, oregano, vanilla, turmeric, and paprika, yields millionaire sums at the expense of the consumer and the reputation of food companies that meet quality standards (Galvin-King et al., 2018).

An example of adulteration of spices occurred in 2014, with ground peanut shells, which were added in powdered cumin. This fact caused a major recall because of the allergenic properties of the peanut material, which is a serious risk for those who suffer from this pathology (Sayers et al., 2016). Another example is Chinese star anise (*Illicium verum*) which is often infused in teas to relieve colic symptoms in children. The adulteration of Chinese star anise with Japanese star anise (*Illicium anisatum*) resulted in the intoxication of children. Japanese star anise is similar to Chinese, as it can be sold broken or ground, it becomes more difficult to distinguish. The Japanese cultivar contains neurotoxins and can result in neurological and gastrointestinal problems in children (Perret et al., 2011).

Curcuma can contain several adulterants that threaten public health, use of yellow chalk powder has been used to add volume to saffron, as it is a cheap and available material. This adulterated product, however, can cause swelling of the face, loss of appetite, nausea, and vomiting. *Curcuma zedoaria* can be used to adulterate curcuma and has been found to have toxic effects on rats and chickens. The lead chromate added to saffron was used as a dye and also as a bulk powder. Overexposure to lead can cause delays in mental and physical development (Oliveira et al., 2019).

The long and complex supply chains and the increase in crushed and ground herbs and spices offer excellent opportunities for fraudulent actions. However, other vulnerabilities that can affect the chances of tampering include seasonality and crop availability, climatic events, cultural and geopolitical events, economic indicators, food security laws, the prevalence of corruption, and advances in technology to mask fraud (BRC-FDF-SSA, 2016). The spice supply chain is considered moderately vulnerable and the main risk factors are simple adulteration, price, competition in the market, and an inadequate detection system in the final products, that is, only standard physical, chemical, and microbiological analyzes are carried out, which do not identify fraud (Oliveira et al., 2019).

In addition to long and complex chains, these can pass through many countries. Supply chain stages can include producer, collector, primary processor, local traders, secondary processor, exporter, importer, trader, processor/packager, food manufacturer/retailer/wholesaler, and, finally, the consumer. At any stage of this supply

chain, several fraud opportunities can occur, including misrepresentation, tampering, and substitution (Galvin-King et al., 2018). Common problems of authenticity associated with spices are the addition of a lower value foreign product and the product's material, which may include the addition of colorants. Ground spices are particularly prone to adulteration because the grinding step changes the shape of the spice and powder adulterant, which makes it difficult to detect adulterants in the final product (Silvis et al., 2017).

The addition of color adulteration to spices to improve their commercial value is a common occurrence. Color can influence the perception of food and stimulate appetite, thus increasing the demand for a particular product. As with other types of food adulteration, there is a likelihood that certain synthetic dyes may pose a threat to public health, and historical records show that injuries and even deaths have occurred after ingesting unacceptable toxic dyes. The two main types of dyes that can be added illegally to foods include azo dyes and triphenylmethanes considered to be genotoxic and or carcinogenic (Galvin-King et al., 2018).

Chemical methods such as high-performance liquid chromatography and mass spectrometry (MS), have been used to determine the presence of external elements or to identify whether the chemical composition is correctly detailed on the label. Like spectroscopic techniques, which are non-destructive, non-invasive, do not use chemical reagents, in some cases, they are less expensive and can be adapted to the dynamism of modern industry (Oliveira et al., 2019). Fraud prevention is not in detecting each individual fraud and controlling a type, but in reducing vulnerabilities, as fraudsters are always evolving and looking to research the next fraud (Galvin-king et al., 2018). While it is the responsibility of governments to define clear legal requirements, it is the responsibility of the industry to mitigate the risks of food fraud (Silvis et al., 2017).

4. Final Considerations

In the different stages of the food production chain, ranging from production in the rural area, from transport logistics to urban centers or as raw material and inputs for industry, opportunities may arise to harm the consumer, adulterating the presence of an ingredient or replacing it with one of lesser commercial value. However, this intentional fraud can lead to irreversible damage to the health of consumers, that is, from the perspective of obtaining greater profits, this harmful crime can have an impact on the health of the most vulnerable populations and cross geographical borders. In this way, "Food Fraud" represents a risk to human health and, therefore, industries must invest in specific and effective analyzes of

production processes, besides, to control measures, actions aimed at reducing or eliminating possible dangers in the processes that contributed to ensuring product quality and safety.

Other works need to be carried out to develop methods capable of detecting food fraud in the entire production chain, from the raw material to the final product. Ensuring food security for consumers, as well as promoting fair competition for those who do not commit fraud.

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