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How the food industry experiences and perceives food fraud

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Abstract

Food fraud becomes one of the main hazards throughout the food chain. The aim of this study was to explore the experiences and perception of food fraud from a food industry perspective and to analyse attitudes of the production/service food sectors in Serbia and Croatia. In total, 53 companies operating in the food chain were included in this research, 36 from Serbia and 17 from Croatia. A cluster analysis was conducted in order to classify companies according to the relative level of the agreement they attach to food fraud. Also, food fraud risk associated with types of food was calculated. Findings identify mislabelling, counterfeiting and substitution as top three types of food fraud. Cluster analysis confirmed differences in perception of food fraud by different types of companies in respect to their size and food sector they operate. Meat products, dairy products, fruit products and honey are types of food most vulnerable to food fraud. On the contrary olive oil, grain products, spices and sauces are products perceived as least likely to be fraud detected. The risk model recognised olive oil and spices as products with the highest perceived fraud risk. This study provides a valuable insight to companies and food technologists operating in the supply chain on how companies perceive food fraud.

Keywords: types of food fraud, perceived fraud, food companies, fraud risk

1. Introduction

Food fraud is considered as an economically driven fraudulent behaviour that comprises of substitution, addition, tampering, or misrepresentation of food, food ingredients or food packaging, false or misleading statements made about a product (Spink and Moyer, 2011). The rapid alert system for food and feed (RASFF) is a tool that ensures flow of information to enable swift reaction when risks to public health are detected in the food chain in the EU. Within this tool, six types of food fraud are recognised: (1) improper, fraudulent, missing or absent health certificate; (2) illegal or unauthorised import, trade or transit; (3) adulteration, fraud or tampering; (4) improper, expired, fraudulent or missing common entry document; (5) expiration date; and (6) mislabelling (EC, 2018). The Global Food Safety Initiative (GFSI) explores seven types of food fraud: (1) substitution; (2) dilution; (3) concealment; (4) mislabelling; (5) grey market production; (6) unapproved enhancements; and (7) counterfeiting (GFSI, 2017).

In most cases, food fraud as economically motivated often results in the reduction of quality, not safety of food. Furthermore, loss of consumer confidence results from food fraud incidents (Moyer *et al.*, 2017). To consider a food product being 'authentic', it must comply with regulations, composition of ingredients, envisaged production and technology practices, and genetic identity (Huck *et al.*, 2016).

Besides the economic background, an increasing concern is the introduction of hazards by food fraud actions which highlights public health risks resulting from fraudulent activities (Bouzembrak and Marvin, 2016). Food fraud as an intentional act can augment food safety risks (Charlebois *et al.*, 2016). These risks are more dangerous than

traditional food safety risks because potential adulterants are unconventional and conventional control/detection systems are not testing food for these contaminants (Kyrova *et al.*, 2017)

One of techniques that could prevent fraudulent activities is through improving the overall traceability of food. As one of the methods in determining geographic origin of seafood, El Sheikha and Montet (2016) recommend new molecular techniques of the traceability based on the assumption that the microbial communities of food are specific to a geographic area. Also, DNA barcoding for the molecular identification of biological specimens, and raw and processed foods may be used as an advanced tool, especially in the meat sector (El Sheikha *et al.*, 2017).

In response to fraudulent activities that occurred over that last decade, the control of food fraud became an integrated part of food laws and food industry practices (Spink *et al.*, 2017). Following a 2012 illegal horsemeat adulteration incident, the European Commission addressed prevention of food fraud within the food integrity area (Lange, 2013). This was followed by other regulatory changes observed in the UK, US and China (Spink *et al.*, 2016).

Bouzembrak and Marvin (2016) identify three edges of the 'food fraud triangle', the victim, the fraudster and the absence of a capable guardian where the area within the triangle represents the fraud opportunity. Van Ruth *et al.* (2017) deploy these three elements of food fraud vulnerability as opportunities (suitable target), motivations (motivated offender) and control measures (guardianship). In response to this, several 'food fraud' models have been development recently, such as the Bayesian Network modelling approach based on RASFF data (Bouzembrak and Marvin, 2016; Marvin *et al.*, 2016) and the initial screening model developed by Spink *et al.* (2016). Charlebois *et al.* (2016) measured consumer's perception towards mislabelled food products as one of the most common fraudulent activities. Organic produce is usually sold at a higher price than their conventional counterparts making organic produce susceptible to fraud (Van Ruth *et al.*, 2013).

Fraud vulnerabilities were analysed in the fish, meat, milk, olive oil, organic and spice supply chains (Van Ruth *et al.*, 2018). Tracing fraud within food chains is very complex as it may involve multiple countries and regulatory bodies where food commodities change hands a number of times, in paper and/or physically (Manning *et al.*, 2016). Extended and fragmented, food supply chains are increasingly vulnerable to fraud, which could occur anytime, anywhere, and in any form (Wang *et al.*, 2017).

The actuality of this topic is also overseen in this decade by the increasing number of publications related to 'food fraud' as a concept or food fraud detection methods and analysis (Huck *et al.*, 2016). Literature review performed by Fassam and Dani (2017) confirmed an increased number of publications (newspapers, academic papers and peer reviewed papers) on food fraud underlining crime and offense, economic background and supply chains as thematic topics. However, limited studies were focused on companies' experiences and attitudes towards food fraud, and this was identified as a research gap by the authors.

The purpose of this study was to explore the perception of food fraud from a food industry perspective and to analyse experiences and attitudes of the Serbian and Croatian food sectors. In the two countries, the food market and small and medium sized food companies represent a major part of the economy. Additionally, this research examined how companies perceived food fraud and calculates food fraud risks associated with different types of food.

2. Materials and methods

Food establishments' characterisation

The data used in this study were collected from the food industry of Serbia and Croatia. Criterion was that food establishments operate in at least one of the parts of the food chain – primary production, food processing, storage/distribution, retail/wholesale or food service establishments (restaurants/caterers). The companies were chosen from all parts of Serbia and Croatia. The authors recognise that this method does not provide a truly random sample of food companies, but instead, represents a 'convenience sample' of such companies and evaluates the companies of the biggest market impact with no territorial bias.

Authors contacted the companies in advance, emphasising that the survey is anonymous and that we wish to distribute the questionnaire related to food fraud. Interviews and data collection lasted approximately one hour. Management representatives from the companies working in production, control and/or research & development sectors participated in the study by answering to the given statements related to food fraud. In total, 53 companies from Serbia and Croatia operating in the food chain producing or trading food were included in the research. The survey was conducted from May 2017 until December 2017 and covered companies from both animal origin and plant origin food sectors. The breakdown of type of companies that participated in this survey is shown in Table 1.

Food fraud in food establishments

A structured questionnaire on food fraud was developed considering similar research (Bouzembrak and Marvin, 2016; Charlebois *et al.*, 2016; NSF, 2014). This questionnaire included general information about the companies, as well as four types of questions related to various dimensions of

Table 1. Number of participating food companies by businesses type and number of employees.

Food businesses type	Number of businesses n[1] (%)	Number of employees		
		<50 n (%)	50-250 n (%)	>250 n (%)
Serbia				
Animal origin food[2]	5 (13.9%)	1 (20.0%)	4 (80.0%)	0 (0.0%)
Plant origin food[3]	22 (61.1%)	7 (31.8%)	8 (36.4%)	7 (31.8%)
Food service[4]	9 (25.0%)	2 (22.2%)	1 (11.1%)	6 (66.7%)
Croatia				
Animal origin food[2]	7 (41.2%)	4 (57.1%)	0 (0.0%)	3 (42.9%)
Plant origin food[3]	7 (41.2%)	0 (0.0%)	6 (85.7%)	1 (14.3%)
Food service[4]	3 (17.6%)	0 (0.0%)	2 (66.7%)	1 (33.3%)
Total		14 (26.4%)	21 (39.6%)	18 (34.0%)

[1] n represents the number of establishments; (%) represents their share in the sample.
[2] Animal origin food covers primary production and food processing of meat and poultry, fish, dairy and eggs.
[3] Plant origin food covers primary production and food processing of fruit, vegetables and beverages.
[4] Food service covers storage, distribution, wholesale, retail and food service establishments.

food fraud. In the first type of questions, the respondents were asked to encircle type of food fraud that comes first to their mind, having seven GFSI definitions of the fraud types as possible answers (GFSI, 2017). The second type gave the respondents the opportunity to rate their degree of agreement on 19 statements according to a five-point Likert scale with the following ranks: 1='strongly disagree'; 2='disagree'; 3='no opinion'; 4='agree' and 5='strongly agree'. In the third type, the companies were asked to rank the type of food that they believe is mostly fraud (from 1='most vulnerable to fraud' to 12='least vulnerable to fraud') and the type of food that is most likely to be fraud detected (from 1='mostly likely fraud detectable' to 12='least likely fraud detectable'). Finally, they had the opportunity to rank the physical state of food most vulnerable to food fraud (from 1='most likely' to 5='least likely') and key contributors to perpetrate fraud (from 1='very important' to 5='not important').

Statistical analysis

A cluster analysis was performed in order to classify companies according to the relative level of the agreement they attach to food fraud and a two-cluster solution was selected. Squared Euclidean distance was a distance measure and Ward's method was used as a connection method. Mann-Whitney U test uncovered statistically significant differences among the clusters. Rank ordered data were analysed by the Friedman test (analysis of variance by ranks) and rank sums were compared by calculating a least significant difference in order to test significant differences (ISO, 2006). The level of statistical significance was set at 0.05. Spearman rank order correlation coefficient (rs) was calculated to measure the strength and direction of association that exists between ranking food most vulnerable to food fraud and detectability of fraud food.

3. Results and discussion

Demographic profile

Out of 60 companies that were included in the survey, 53 answered to all statements related to food fraud. Overall demographic profile of the companies (Table 1) shows that 36 companies are located in Serbia and 17 in Croatia. The difference in per-country sample size is not relevant for data analysis as the goal of the study was not to make country-based comparisons. Distribution of the companies regarding their size is rather similar. Food companies operating in the animal origin production chain and the food service sector participated with 22.6% each. The remaining companies came from the plant origin food production chain.

Statements related to food fraud

Companies had the opportunity to answer which type of food fraud first comes to their mind. The top three types were mislabelling (35.8%), counterfeiting (18.9%) and substitution (13.2%). Dilution was the least mentioned type of food fraud. Mislabelling is a very wide type of food fraud, where marketability and brand equity can be included in this food fraud (Charlebois *et al.*, 2016). Substitution of high valued products with cheaper ones is often seen with fish in restaurants as presented in works of Christiansen *et al.* (2018) and Kappel and Schröder (2016). Production of seafood faces many challenges including the over-exploited

natural stocks, global warming, pollution, perishability, widespread food frauds, and food-borne diseases (El Sheikha and Xu, 2017).

A two-step cluster analysis using country, company size and food sector as categorical variables was performed. As a result, two clusters were defined (Table 2). Overall results show that the highest level of agreement among the companies was regarding the statement that profit is the main trigger for food fraud (4.5) and that availability and ease of adulteration/substitution enables food fraud (3.9). Main reason for adulteration is the substitution of highly valuable ingredients by similar but cheaper ones (Huck *et al.*, 2016). Best example to confirm these results is the horsemeat illegally mixed into beef products in the UK where horsemeat as an adulterant – substance was used in

Table 2. Description of the two clusters in terms of country, size of company and food sector (n=53).[1,2,3]

		Cluster 1 (n=33)	Cluster 2 (n=20)	Total (100%)
Country	Serbia	20 (55.6%)	16 (44.4%)	36
	Croatia	13 (76.5%)	4 (23.5%)	17
Size	Small	6 (42.9%)	8 (57.1%)	14
	Medium	16 (76.2%)	5 (23.8%)	21
	Big	11 (61.1%)	7 (38.9%)	18
Sector	Animal origin food	6 (50.0%)	6 (50.0%)	12
	Plant origin food	22 (75.9%)	7 (24.1%)	29
	Food service	5 (41.7%)	7 (58.3%)	12
Regulatory agencies can always be trusted to monitor counterfeiting or food fraud		2.6±0.8[a]	2.1±0.8[b]	2.4±0.8
Regulatory agencies can always be trusted to be vigilant and when necessary take action against fraudulent companies		2.6±0.9	2.2±0.7	2.5±0.8
Regulatory agencies do a great job in making sure that all food products are properly labelled		3.3±0.8[a]	2.3±0.8[b]	2.9±1.0
My suppliers can always be trusted to be vigilant and when necessary take action against other fraudulent food companies		3.7±0.7[a]	2.4±0.8[b]	3.2±0.9
My suppliers can always be trusted to monitor counterfeiting or food fraud		3.8±0.6[a]	2.4±0.6[b]	3.2±0.9
My suppliers do a great job in making sure that all food products are properly labelled		4.0±0.5[a]	3.0±0.8[b]	3.6±0.8
Physical state of food enables food fraud		3.6±0.9	3.6±0.7	3.6±0.8
Availability of adulterants/substitutes enables food fraud		3.9±0.8	4.0±0.5	3.9±0.7
Ease of adulteration/substitution enables food fraud		3.9±0.7	4.0±0.3	3.9±0.6
Labelling/tamper-proofing enables food fraud		3.8±0.7	3.7±0.7	3.8±0.7
Profit is the main trigger for food fraud		4.4±0.7	4.6±0.8	4.5±0.7
Low likelihood of detection is the main trigger food fraud		3.6±1.0	3.3±1.1	3.5±1.0
In the last 12 months, we experienced improper, fraudulent, missing or absent health certificate as food fraud from suppliers		1.5±0.7[a]	3.1±1.1[b]	2.1±1.1
In the last 12 months, we experienced illegal or unauthorised import, trade or transit as food fraud from suppliers		1.4±0.7[a]	2.5±1.1[b]	1.8±1.0
In the last 12 months, we experienced adulteration, tampering, substitution, dilution as food fraud from suppliers		1.4±0.5[a]	2.6±1.1[b]	1.8±1.0
In the last 12 months, we experienced improper, expired or missing import declaration/ docs as food fraud from suppliers		1.4±0.5[a]	2.9±1.1[b]	2.0±1.0
In the last 12 months, we experienced expiration date as food fraud from suppliers		1.4±0.6[a]	2.8±1.2[b]	1.9±1.1
In the last 12 months, we experienced mislabelling as food fraud from suppliers		1.5±0.6[a]	3.0±1.1[b]	2.1±1.1
In the last 12 months, we experienced theft and resale as food fraud from suppliers		1.4±0.5[a]	2.1±0.8[b]	1.7±0.7

[1] Items denoted with different letters are significantly different at the level of 5%.

[2] Likert scale: (1) 'Strongly disagree', (2) 'Disagree', (3) 'No opinion', (4) 'Agree', (5) 'Strongly agree'.

[3] Definitions of food fraud presented to interviewees: substitution (one ingredient partially substituted with another); dilution (watered down products suing water or other liquid); concealment (hiding some characteristics of food such as food colouring to cover defects); mislabelling (stating wrong information on labels); grey market production (sale of excess unreported product); unapproved enhancements (use of unauthorised ingredients); counterfeiting (copies of popular foods – not produced with acceptable quality assurances).

beef to gain profit since pricing per ton for beef is estimated at $5,300 (USD) while horsemeat is approximately $1,300 (Moyer *et al.*, 2017). It is known that meat products are targets for species substitution and adulteration due to their market value (El Sheikha *et al.*, 2017). Another example is the Lafite-Rothschild 1982 wine where more bottles were sold than were released on the market (Lecat *et al.*, 2017).

Cluster 1 (33 companies), consists of the majority of companies from Croatia and half from Serbia, medium sized and big companies and companies that operate in the plant origin production chain. The statements of food fraud prevailing in this cluster are that they mostly trust their supply chain in terms of taking actions against fraudulent food companies (3.7), monitoring counterfeiting (3.8) and proper food labelling (4.0). These companies didn't experience food fraud coming from their suppliers.

Cluster 2 (20 companies) consists from companies operating in Serbia, mainly small sized companies and companies operating in the food service sector. They mostly don't trust their suppliers (answers below 2.5) and have no opinion on whether they experienced any food fraud from their suppliers (answers around 3.0) since they have no monitoring system in place. These results are in concurrence with the spice supply chain research where medium and large companies have a food fraud supply chain monitoring system while small companies lack any resources to build a fraud mitigation plan (Silvis *et al.*, 2017). Supply chain fraud is driven by market competition and affect the integrity of food, the processes used to produce food, the people employed and the data accompanies with food (Manning, 2016).

Both clusters don't trust regulatory agencies towards fighting food fraud. It is interesting that a research on measuring consumer perception towards food fraud suggests that there is a strong correlation between the level of trust of consumers in regulatory agencies and the level of trust towards the food supply chain (Charlebois *et al.*, 2016). Statistically significant differences between clusters are observed for statements related to regulatory agencies, suppliers and food fraud experience in the last 12 months (P<0.05).

Ranking fraud food

A set of questions was prepared to assess type of food most vulnerable to food fraud, physical state of food most vulnerable to food fraud, type of fraud food that is most likely to be detected and key contributors to perpetrate fraud. The results are shown in Tables 3-6, respectively.

Among 12 types of food, the companies were asked to rank type of food most vulnerable to food fraud (Table 3). The highest ranked type of food was 'meat and meat products' (P<0.05). The second group of products consists of milk and dairy products, fruit products and juices, honey, olive oil, alcohol drinks and fish. This is in line with the two most famous mislabelling issues in the last 10 years known as the European horsemeat scandal in 2013 and the Chinese milk scandal in 2008 (Huck *et al.*, 2016). Vegetables, nuts and nut products were not highly ranked. Based on previous studies related to RASFF notifications, fish (and fish products) and meat (and meat products) were the most reported product categories in the EU (Bouzembrak and Marvin, 2016). Notifications that were recorded in the RASFF database under the hazard category 'fraud' during the period 01/01/2000 to 31/12/2017 confirm 1,202 notifications where 'meat and meat products' participate with 16.97%. Food with the highest number of notifications were 'nuts and nut products' with 20.22% (EC, 2018).

Table 3. Type of food that is most vulnerable to fraud.

Type of food	Rank sum[1,2] Homogeneous subsets for α=0.05					
	1	2	3	4	5	6
Meat and meat products	136					
Milk and dairy product		247				
Fruit product and juices		266				
Honey		296	296			
Olive oil		302	302			
Alcohol drinks/spirits		317	317			
Fish		319	319			
Spices			368	368		
Sauces				423	423	
Cereals/grains/flour				432	432	
Vegetables and products					476	476
Nuts and nut products						552

[1] n=53 (complete block design).
[2] The attributes were ranked from 1 'most vulnerable to fraud' to 12 'least vulnerable to fraud'.

Results from Serbian and Croatia confirm research from Van Ruth *et al.* (2018) where meat was identified as a product with the highest opportunities related to fraud factors. In China, animal origin products have occurred in several media fraud reports (Zhang and Xue, 2016). In Asia there were several cases of food fraud present in media, such as misidentified fish or meat products, or recycling of waste oils into products sold for human consumption (Corke, 2015).

Additionally, companies were asked to rate the physical state of food most vulnerable to food fraud (Table 4). Powder and liquid products were highly ranked. Fresh solid food is

Table 4. Physical state of food that is most vulnerable to fraud.

Physical state	Rank sum[1,2] Homogeneous subsets for α=0.05		
	1	2	3
Powder	120		
Liquid	124		
Heterogeneous	153	153	
Solid (frozen)		182	182
Solid (fresh)			216

[1] n=53 (complete block design).
[2] The attributes were ranked from 1 'most vulnerable to fraud' to 12 'least vulnerable to fraud'.

the state of products that is least likely to be fraud. These results are in concurrence with one of the latest NSF studies stating liquid and powder food as easy to fraud and fresh and whole food items as difficult to fraud (NSF, 2014).

In relation to the possibility of detecting food fraud, companies were asked to rank fraud foods that are most likely to be detected (Table 5). They believe that fraud honey is easily detectable joint with fruit products, meat and dairy products. On the contrary, spices and sauces are types of food where fraud is least likely to be detected. Spices represent an attractive category for potential offenders, because of its high value and limited capacity to detect adulteration (Moore *et al.*, 2012). Ingredients mostly substituted are chilli, oregano, cumin, black pepper, cinnamon, saffron and turmeric (Galvin-King *et al.*, 2018). Fish and spice chains were identified as food with the greatest lack of (adequate) control measures and detectability in the fraud vulnerability study performed by Van Ruth *et al.* (2018).

Table 5. Type of fraud food that is most likely to be detected.

Type of food	Rank sum[1,2] Homogeneous subsets for α=0.05				
	1	2	3	4	5
Honey	257				
Fruit product and juices	257				
Meat and meat products	273				
Milk and dairy product	284	284			
Vegetables and products	303	303	303		
Fish	329	329	329	329	
Alcohol drinks / spirits	349	349	349	349	
Nuts and nut products		388	388	388	388
Olive oil			399	399	399
Cereals / grains / flour			401	401	401
Spices				426	426
Sauces					468

[1] n=53 (complete block design).
[2] The attributes were ranked from 1 'most likely to be fraud detected' to 12 'least likely to be fraud detected'.

Importance of fraud detection is also emphasised in the research of Tähkäpää *et al.* (2015) where the most common reasons for fraud/adulteration notification reported in RASFF were illegal or unauthorised trade/import/transit and improper/missing/fraudulent health certificates. Out of 1,202 food fraud notifications reported for the period 2000-2017 'improper, fraudulent, missing or absent health certificate' was reported in 53.74% cases followed by 'illegal or unauthorised import, trade or transit' in 29.2% cases (EC, 2018). Detection is the most important control tool and as such is widely researched and supported by traditional food science (Spink *et al.*, 2015).

Finally, companies believe that the key contributors to perpetrate food fraud are process of adulteration/substitution and availability of adulterant (Table 6). Adulteration of food is considered as an industrial and a governmental responsibility (Kyrova *et al.*, 2017). On the other side, high level of supply chain assurance is not important in perpetrating fraud. NSF study shows the same key contributors that perpetrate fraud (NSF, 2014).

Spearman rank correlation was conducted using all answers gathered during the survey. Regarding the subset of data related to ranking of food most vulnerable to food fraud and fraud food that is most likely to be detected, a significant correlation was found (rs=0.267, $P<0.01$, N=53).

Table 6. Key contributors to perpetrate fraud.

Contributors	Rank sum[1,2] Homogeneous subsets for α=0.05		
	1	2	3
Process of adulteration/substitution	103		
Availability of adulterant	124		
Labelling		163	
Physical state of food		177	
High level of supply chain assurance			228

[1] n=53 (complete block design).
[2] The attributes were ranked from 1 'very important' to 5 'not important'.

Food fraud risks

Requirements outlined in food safety standards and the GFSI recommend companies to evaluate risks associated with food fraud (FSSC, 2015; GFSI, 2014). Spink *et al.* (2016) propose a risk model recognising various food fraud impacts. They agree that assessment criteria are difficult to develop due to the difficulty in comparing and aggregating food fraud risks across companies. In order to perform evaluation of risk and develop a risk matrix, it is common to use likelihood and severity as risk categories (ISO, 2018). However, based on the results from this survey, slight adaption of the model included the following criteria:

- Food most vulnerable to food fraud with the following ranking scales that enable meaningful differentiation for ranking: 'high likelihood' with rank value '3' – first four products listed in Table 3; 'middle likelihood' with rank value '2' – products listed in positions 5 to 8; 'low likelihood' with rank value '1' – last four listed food products.
- Fraud food that is most likely to be detected with the following ranks: 'high detectability' with rank value '1' – last four products listed in Table 5; 'middle detectability' with rank value '2'– products listed in positions 5 to 8; 'low detectability' with rank value '3'– first four products listed food products.

Food fraud risk was calculated according to the equation R=V×D, where R stands for risk, V for vulnerability and D for detectability. This risk model recognised olive oil and spice as products with the 'highest' risk for their medium level of food fraud likelihood and low level of food fraud detectability, as ranked by companies in Serbia and Croatia (Figure 1). This is in concurrence with research of Silvis *et al.* (2017) emphasising the spice industry joint with meat, fish and olive oil industry are the most vulnerable. In order to respond to such risks, food defence practices could be employed such as 'threat assessment and critical control points' (TACCP) or 'vulnerability analysis and critical control points' (VACCP) to address food fraud threats in the supply chain and/or vulnerability of the suppliers (Davidson *et al.*, 2017).

Practical implication and limitation of the study

From a food policy point of view, these findings invite stakeholders in the food chain, mainly producers, suppliers and regulatory agencies, to work on re-gaining trust regarding food fraud. Also, this research provides an added value regarding analysis of the current level of understanding of food fraud in the food sector. Cluster analysis confirmed differences in perception of food fraud by different types of companies and food sectors they operate. The results may also be of interest for consultants and managers of food companies interested in shifting their views of food safety to a broader food fraud value chain perspective.

Limitations of this study are that only two countries participated in the research and artisanal production was

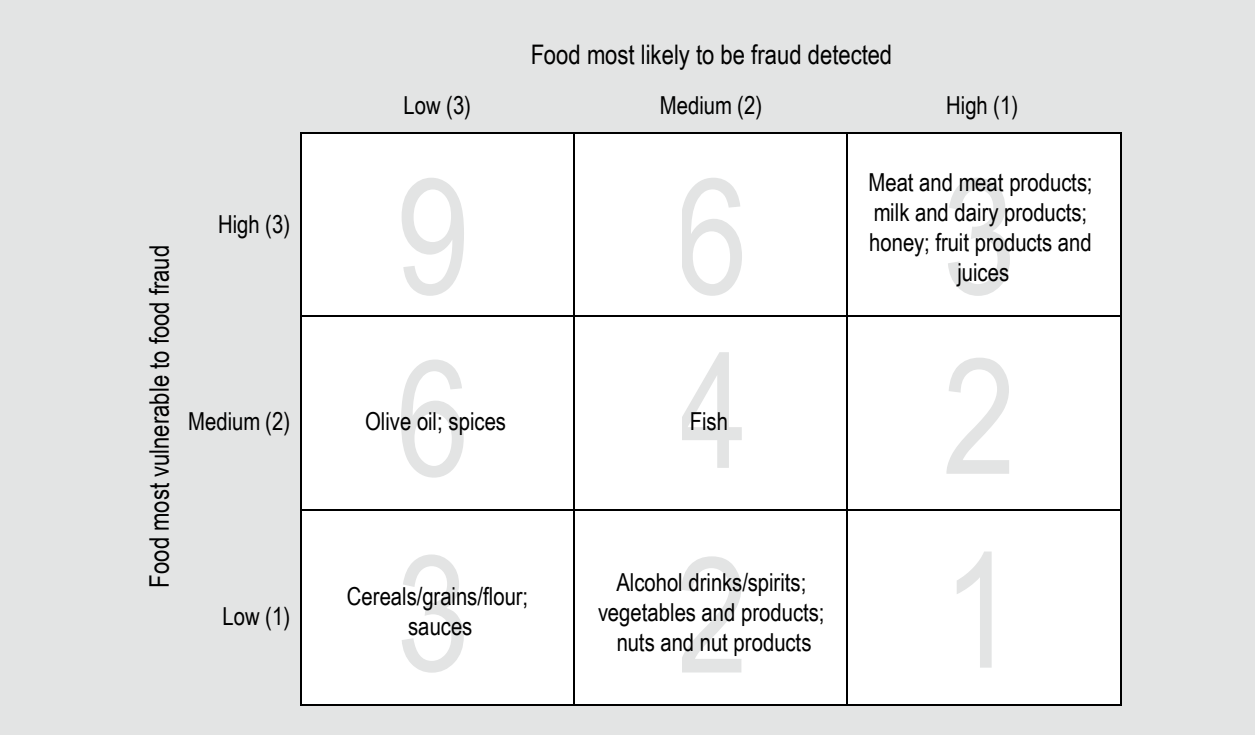

Figure 1. Food fraud risk map.

not included. Further research should focus on clarifying the role of small and medium enterprises (both as customers and suppliers) in food fraud as well as collecting data from other countries in Europe in order to enhance the generalisation. Another limitation is that this research was focused on companies' perceptions and beliefs related to food fraud and not measurement of any characteristics of food.

4. Conclusions

Results obtained from this research highlight mislabelling, counterfeiting and substitution as top three types of food fraud. Mislabelling of food, either accidentally or deliberately, can pose food safety issues while counterfeiting and substitution are mainly related to deterioration of quality of food.

Regarding types of food, meat products, dairy products, fruit products and honey are products that are perceived as most vulnerable to food fraud. On the other side olive oil, grain products, spices and sauces are products perceived as least likely to be detected. The risk model identified olive oil and spices as food with the highest perceived food fraud risk.

Addressing food fraud should lead to expanding both food safety and food quality dimensions, depending on the type of food fraud. Focus should be on expanding food science and technology research towards fraud root cause analysis, new detection methods and process versus product verification for food fraud, food business decision-making as well as social sciences and fraud criminology.

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