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FOOD ADULTERATION AND SAFETY REGARDING DETECTED MARKET CASES AND CONSUMER OPINIONS

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ABSTRACT
Food fraud is one of the long-standing causes of scandals attracting particular attention for a long time. This study aimed to monitor food fraud in the European Union and to identify the relationships among the countries where the cases were reported, adulterated commodities (seafood, eggs, milk, meat, fish, and their products) and types of fraud. The secondary data were covered by the survey focused on consumer knowledge about fraudulent activities, ingredient substitution, masking of origin, mislabeling, placing on the market of foods not fit for human consumption within Slovak inhabitants. Primary and secondary data were used to achieve this aim. Primary data were obtained from the Food Fraud and Quality Knowledge Center (KCFFQ) and secondary data from the questionnaire survey from 354 respondents. During the period from 2017 to 2019, 163 cases of food fraud were reported, most of which originated from Italy and mainly concerned fish and fish products. Based on primary data and one-way ANOVA statistical tests, we confirmed five hypotheses. There was found no statistical impact of the country on the type of food fraud ($p = 0.0067$), but the significant effect was determined on which food was adulterated ($p = 0.000001$). There was no statistical correlation among years and countries where the cases were reported ($p = 0.110$), but the statistically significant correlation was confirmed among years and commodities ($p = 0.0043$) and types of fraud reported ($p = 0.009$). Based on the processed secondary data from the questionnaire, we can conclude some information or public interest in food fraud problems.

Keywords: food fraud; KCFFQ; consumers; adulteration; questionnaire

INTRODUCTION
Adulteration in food has been a concern since the beginning of civilization, as it not only decreases in the quality of food products but also results in several ill effects on health. Authenticity testing of food and adulterant detection of various food products is required for value assessment and to assure consumer protection against fraudulent activities. Concerns about food safety and regulation have ensured the development of various techniques such as physical, biochemical/immunological, and molecular techniques, for adulterations detection in food **(Bansal et al., 2017)**. Food fraud, the intentional misrepresentation of the true identity of a food product or ingredient for economic gain, is a threat to consumer confidence and public health and has received increased attention from both regulators and the food industry **(Everstine et al., 2018)**. Every European citizen has the right to know how the food he eats is produced, processed, packaged, labelled, and sold. The implementation of this integrated Food Safety policy in the EU involves various actions, namely to assure effective control systems and evaluate compliance with EU standards in the food safety and quality, animal health, animal welfare, animal nutrition and plant health sectors within the EU and in non-EU countries in relation to their exports to the EU; to manage international relations with non-EU countries and international organisations concerning food safety, animal health, animal welfare, animal nutrition, and plant health; to manage relations with the European Food Safety Authority (EFSA) and ensure science-based risk management **(European Commission, 2020a)**. Rapid alert system for the notification of a direct or indirect risk to human health deriving from food or feed was established in the EU. It involves the Member States, the Commission, and the EFSA **(Regulation (EC) No 178/2002)**. Starting from November 2015 a dedicated IT application known as the Administrative Assistance and Cooperation System (AAC) has been made available for the Member States. After a successful period of testing dealing with fraudulent practices in the agri-food chain, in 2016 the system was also opened to liaison bodies based on official controls. The AAC and RASFF (Rapid Alert System for Food and Feed) are working together in synergy to keep the high EU standards for food and feed **(EU, 2017; RASFF, 2018)**.

The Knowledge Centre for Food Fraud and Quality provides and shares up-to-date scientific knowledge on food fraud and food quality issues. It coordinates market surveillance activities and operates early warning and information system for food fraud. Collectively is operated by the European Commission's science and knowledge

service, the Joint Research Centre (JRC), and the Departments regulating the feed-food chain and protecting consumer rights. The Centre complements the activities of the EU Food Fraud Network, which is operated by the European Commission Department for Health and Food Safety **(European Commission, 2020b)**.

Scientific hypothesis

The first objective of this study was to monitor the food fraud focused mainly on the food of animal origin in member states of the European Union and to identify the most common reasons for these cases. The following hypotheses concerning food fraud were set up as follows:
Hypothesis 1: We assume no statistical evidence of the country's impact on food frauds, which were reported.
Hypothesis 2: We assume statistical evidence of the country's impact on counterfeit foodstuff.
Hypothesis 3: We assume no statistical evidence between the countries and year when the food fraud cases were reported.
Hypothesis 4: We assume statistical evidence between adulteration of food and the year of its occurrence.
Hypothesis 5: We assume statistical evidence between the type of food fraud and year of its occurrence.

The second objective was to find out consumer awareness in Slovakia regarding their knowledge and opinion on food fraud.

MATERIAL AND METHODOLOGY

The objective of this paper was achieved by using and processing of primary and secondary data. Primary data were obtained from the Knowledge Centre for Food Fraud and Quality (KCFFQ) which is hosted by the Joint Research Centre (JRC), during the period 2017 – 2019. The records were obtained using the portal contained information about:

- the reporting country,
- the food commodities,
- categories of food fraud,
- accurate case information.

The data obtained became the basis for confirming or rejecting hypotheses.

Secondary data were obtained using the survey focused on identifying consumers' awareness of food fraud in the Slovak Republic. The questionnaire was performed at a sample of 354 respondents in the 2019 year, using the Google Forms platform. The respondents were diversified into 2 categories in terms of gender and age. Women were represented by the amount of 278 (78.5%). The men were represented by 76 respondents (21.5%). Group was also divided into four groups based on their age. The age structure consisted as follows: from 16 to 21 years (13.3%), from 22 to 30 years (41.2%), from 31 to 45 years it was 27.1% and from 46 to 70 it was 18.4%. Questions about which commodities are most often adulterated, which types of food fraud occur most often, in which countries they think food fraud is the most commonly reported, and from what media they get this information was given to respondents.

Statistical analysis

The collected data were processed using the statistical program XLSTAT (Addinsoft, version 2019.1.2) The formulated hypotheses were tested using the one-way ANOVA statistical test. Hypotheses were tested: if the *p*-value is less than a significant level (0.05) the invalid hypothesis was rejected and an alternative hypothesis was confirmed.

RESULTS AND DISCUSSION

Analyzes of primary data from KCFFQ

Food safety is one of the crucial issues of public health protection **(Cieslik and Cieslik, 2012)**. If food is misdescribed, i.e. the information about the origin, composition, etc. provided to customers is not true and if this misdescription is done to deceive the customer for financial gain, food fraud, also known as economically motivated adulteration, is committed. Economically motivated adulteration of food is estimated to cause damage of around €8 to €12 billion per year **(Vaqué and Vidreras, 2018)**.

By evaluating food fraud notifications at KCFFQ during years from 2017 to 2019, we found 163 notifications reported to the KCFFQ system (Table 1a, 1b, 1c, 1d, 1e, and 1f). We evaluated the ten most common types of fraud, 12 reporting countries, 5 commodities that were most commonly adulterated. There were found 60 notifications in 2017, where in Slovakia was reported only one case. This notification involved meat originating from Brazil contaminated with *Salmonella*.

The next year 2018, showed the highest amount of notifications for the whole observed period, namely 72.
In 2019 there were found 31 reports. In Slovakia, no notification of food fraud was reported in the year 2018 and 2019. Reports of food fraud in each country from 2017 to 2019 in Europe are shown in Figure 1. Within this period, 92 reports were received from Italy, of which 37 concerned fish and fish products. Spain received 25 reports, also related to fish and fish products. 12 reports originated from the UK and 8 of them related to meat and meat products. 7 reports were reported from Belgium and Portugal, in both countries 6 cases related to meat and meat products, together 6 cases originated from France and 4 related to fish and fish products. 5 cases were reported from the Netherlands with 3 concerning the eggs. 3 cases from Ireland related to meat and meat products, Malta, Poland, and Slovakia reported one case of meat fraud and Germany reported one case of egg fraud.

Čapla et al. (2019) published a review on different types of foreign matter detected in food, reported by the RASFF during the period from 2016 to 2018. The presence of foreign bodies in food from different European regions showed differences. Plastic, glass, and metal were the most commonly reported in Western Europe, pests, and rubber in Northern Europe. As far as food commodities are concerned, bakery and confectionery products, fruit and vegetables, and convenience foods were the most frequently reported and the notifications originated often from Western Europe. Notifications from this part of Europe were made concerning other monitored commodities as well. Regarding the notification type, the most frequent one was an alert, and, in the case of a risk decision, serious risk constituted the largest part. Following updates to food safety certification standards and publication of new U.S. regulatory requirements, **Everstine et al. (2018)** undertook

a project to develop a scheme to classify food fraud-related adulterants based on their potential health hazard and apply this scheme to the adulterants listed in a database of 2,970 food fraud records. The classification scheme was developed by a panel of experts in food safety and toxicology from the food industry, academia, and the U.S. Food and Drug Administration. Results reinforce the importance of including a consideration of food fraud-related adulterants in food safety systems.

Regarding the particular problems found in our evaluation, we can see several kinds of foods reported as the problem with traceability (from Italy, Spain, Portugal, France, etc.). For example, Italy reported at 3.5 mil. eggs, that they were found to be untraceable.

Table 1a An overview of food frauds in 2017 – 2019 in the order in which they were reported.

Country	Commodity	Food fraud	Details
2017			
Italy	fish and fish products	mislabelling	incorrect labeling of fish during the Christmas period
Italy	fish and fish products	mislabelling	fish were not traceable
Italy	fish and fish products	artificial enhancement	dyeing low quality tuna to sell it as fresh fish
Italy	milk and milk products	counterfeit	counterfeiting of mozzarella (discovery of labels of a well-known dairy company stored along with cow milk from other companies)
UK	meat and meat products	substitution	selling turkey instead of halal lamb
Italy	milk and milk products	artificial enhancement	spoilt milk was treated with caustic soda to mask acidification and aging
Italy	milk and milk products	Substitution	replacement of buffalo milk for cow's milk
Italy	milk and milk products	artificial enhancement	smoked Provolone cheese with cardboard and printed and glued paper leaflets.
Spain	seafood	mislabelling	no records of octopus traceability
UK	meat and meat products	origin masking	claimed their lamb products had been 'Produced in Britain' but in fact contained traces of imported New Zealand meat
Italy	meat and meat products	origin masking	using inappropriate animals to produce the cured ham and forging documents to reconstruct the traceability of the meat
Netherland	meat and meat products	substitution	sold horse meat as beef
Netherland	fish and fish products	substitution	endangered shark found in several fish products
Italy	eggs	origin masking	declaration of origin and other labelling information were missing
Italy	fish and fish products	mislabelling	lack of or incomplete informations about traceability
Italy	fish and fish products	mislabelling	untraceable fish products
Italy	seafood	mislabelling	untraceable seafood products
Spain	fish and fish products	mislabelling	lack of traceability and proper labelling
Slovakia	meat and meat products	products not fit for consumption	meat coming from Brazil contaminated with *Salmonella*
Portugal	milk and milk products	mislabelling	untraceable fozen goat milk
Italy	fish and fish products	mislabelling	mislabelling and traceability problem
Italy	eggs	mislabelling	absence of labelling, making it impossible to determine the origin of the eggs
Italy	fish and fish products	mislabelling	mislabelling juvenile fishe
Italy	fish and fish products	illegal equipment	use of illegal equipment and catch of juvenile fishe
Spain	fish and fish products	mislabelling	lack informations or mislabelling of origin
Italy	milk and milk products	origin masking	doubts about the true origin of dairy products
Italy	meat and meat products	substitution	sale of pork sausages instead of advertised wild boar and deer sausages
Italy	fish and fish products	substitution	red tuna was substituted by Yellowfin tuna and grouper was replaced by cheaper Nile perch in restaurant
Spain	meat and meat products	substitution	adding pig meat, soy and bread to their beef burgers and meatballs

Table 1b An overview of food frauds in 2017 – 2019 in the order in which they were reported.

Country	Commodity	Food fraud	Details
2017			
Portugal	meat and meat products	products not fit for consumption	lack of veterinary controls; lack of traceability; expired food relabelled with a new expiry date
Italy	fish and fish products	mislabelling	mislabelling of fish
Italy	fish and fish products	substitution	bluefin tuna was sold as a cheaper Albacore fish
Spain	meat and meat products	products not fit for consumption	distributing horse meat (horses were too old or labelled as "unfit for consumption")
Belgium	meat and meat products	products not fit for consumption	distributing horse meat (horses were too old or labelled as "unfit for consumption")
Italy	food	mislabelling	selling frozen food in restaurant without properly informations on the menu
Italy	fish and fish products	products not fit for consumption	expired and/or unlabelled products
Italy	eggs	mislabelling	traceability problems
UK	meat and meat products	substitution	horse meat and regular beef were sold as 100% beef
Italy	eggs	contamination	high levels of fipronil detected
Netherland	eggs	contamination	high levels of fipronil detected
Belgium	eggs	contamination	high levels of fipronil detected
Germany	eggs	contamination	high levels of fipronil detected
United Kingdom	fish and fish products	mislabelling	labels of other companies were used to by-pass the Russian law limiting the number of UK exporters
Italy	milk and milk products	origin masking	cheese were produced in unregistered places, labelled with incorrect information and entered fraudulently the Fontina DOP production chain
Italy	fish and fish products	mislabelling	unlabelled fish products
Italy	milk and milk products	origin masking	dairy farms were not accredited for the production of cheese with a protected origin and re-used old labels to pass the product as authentic
Spain	fish and fish products	artificial enhancement	the nitrites contained in the vegetables give the tuna a bright red colour making it appear fresher
Italy	milk and milk products	origin masking	labelling rules concerning claims made on the geographical origin and/or being organic were falsed claims
Italy	fish and fish products	mislabelling	unlabelled fish and molluscs
Italy	food	mislabelling	food without any traceability
Italy	fish and fish products	mislabelling	problems of traceability and compliance to mandatory labelling
Spain	fish and fish products	mislabelling	untraceable and unlabelled tuna
Italy	meat and meat products	mislabelling	of poor hygiene and non-traceability distibuted to schools, hospitals and military canteens
Italy	eggs	mislabelling	3.5 million eggs were found to be untraceable
Italy	fish and fish products	mislabelling	fish were found with irregularities concerning the labelling and traceability
Spain	fish and fish products	artificial enhancement	dyeing low quality tuna to sell it as fresh fish
Italy	fish and fish products	mislabelling	mislabelling of fish
Italy	fish and fish products	substitution	Bluefin tuna was sold as a cheaper Albacore fish
Italy	fish and fish products	mislabelling	health inspection, origin, date of freezing and traceability documentation were missing
Italy	milk and milk products	mislabelling	untraceable products in the food chain

Table 1c An overview of food frauds in 2017 – 2019 in the order in which they were reported.

Country	Commodity	Food fraud	Details
Spain	seafood	mislabelling	the origin of the product could not be determined as the mandatory labelling was missing
2018			
Spain	fish and fish products	mislabelling	fish that could not be traced
Spain	fish and fish products	substitution	restaurants were selling other types than those on offer (replaced by sole, hake and bluefin tuna)
Italy	fish and fish products	mislabelling	sale of frozen foodstuffs as fresh food of incorrect Italian origin
Italy	meat and meat products	origin masking	sale of frozen foodstuffs as fresh food of incorrect Italian origin
United Kingdom	meat and meat products	substitution	lamb meat (animal <12 months) has been replaced by mutton meat (older animal)
Italy	fish and fish products	origin masking	the shellfish was not traceable and the documentation of origin was missing
Italy	milk and milk products	mislabelling	Untraceable food
Italy	fish and fish products	mislabelling	Untraceable food
Belgium	meat and meat products	mislabelling	minced meat witch the expiry dates of the products were falsified
Spain	seafood	origin masking	Portugal clams were sold as Galician clams
Belgium	meat and meat products	substitution	conventional meat were sold as organic meat
Italy	food	origin masking	the traceability documentation were missing
Spain	meat and meat products	products not fit for consumption	freezing products; adding warm water, viscera and pork blood to cows to increase body weight; the product has expired 3 years ago and products contaminated with S*almonella*
Italy	meat and meat products	origin masking	improper marketing of meat with registered trade mark
Ireland	meat and meat products	products not fit for consumption	horse meat imported from eastern countries were unfit for human consumption; sold without true evidence on the Irish market
Italy	fish and fish products	products not fit for consumption	distribution of expired ten tonnes of frozen fish
Italy	meat and meat products	counterfeit	Danish Duroc boars have been used instead of Italian pig breeds for insemination purposes to reduce the fat content of the hams produced
Italy	fish and fish products	mislabelling	lack of appropriate traceability documentation for tuna, salmon and other types of fish
Italy	fish and fish products	mislabelling	lack of appropriate traceability documentation for fish products
Italy	fish and fish products	products not fit for consumption	use low quality fish to prepare sushi and sashimi; offered frozen fish that have expired
France	fish and fish products	products not fit for consumption	fillets were sold as fresh fish, although they were actually frozen
France	fish and fish products	artificial enhancement	use of unauthorized additives to improve the red color of tuna
France	fish and fish products	artificial enhancement	salt, potassium lactate, potassium acetate, citric acid and polyphosphate were used to retaining water
Italy	milk and milk products	mislabelling	the product was not made with PDO cheese from Bergamo as indicated on the label
Belgium	meat and meat products	products not fit for consumption	poultry meat with a counterfeit expiry date were sold
Italy	meat and meat products	origin masking	counterfeiting ham with PDO San Daniele

Table 1d An overview of food frauds in 2017 – 2019 in the order in which they were reported.

Country	Commodity	Food fraud	Details
United Kingdom	eggs	mislabelling	the sale of eggs at high prices whilst they were free range eggs that did not actually meet the criteria
Italy	milk and milk products	substitution	false mozzarella di bufala DOP and other type of cheese were sold to tourists
Spain	meat and meat products	products not fit for consumption	ham and other types of meat that were expired, were re-labelled and re-introduced into the market
Italy	food	substitution	substitution of organic products by conventionally produced products; lack of hygiene and traceability of the products
Italy	food	products not fit for consumption	rotten foods, in some cases after the expiry date was relabelled and intended to be offered for sale
Spain	meat and meat products	mislabelling	the hams in the packages were sold with a changed expiration date or were rotten
Italy	fish and fish products	products not fit for consumption	defrosted fish placed on the market from a fishing shop that did not meet the hygiene conditions laid down by law were seized
Portugal	meat and meat products	products not fit for consumption	found rotten meat stored under unsuitable conditions
Italy	fish and fish products	products not fit for consumption	part of the fish was supposed to be sold fresh, but in fact it was rotten
Spain	fish and fish products	smuggling	endangered Spanish eel species smuggled into Japan via China
Italy	fish and fish products	mislabelling	fish were found without traceability documents
Spain	fish and fish products	artificial enhancement	fish that was caught by boats not equipped with the appropriate freezers were treated with additives to mimic the appearance of fresh fish
Spain	fish and fish products	counterfeit	canned tuna were sold as fresh tuna
Italy	fish and fish products	products not fit for consumption	fish in a restaurant was not fit for human consumption
Italy	food	mislabelling	mislabeling and missing food traceability documents
United Kingdom	meat and meat products	substitution	meat products were sold and produced from unspecified meat (the species was not mentioned on the label)
Italy	food	products not fit for consumption	meat and fish unfit for human consumption were sold in a restaurant
Italy	meat and meat products	counterfeit	ham was not produced according to the mandatory compliance process to be labelled as "Crudo di Parma"
Italy	fish and fish products	products not fit for consumption	non-compliance with hygiene regulations for the storage and handling of fish in markets and restaurants
Italy	milk and milk products	counterfeit	cheese sold with the false labels of the Pecorino Crotonese PDO cheese
Ireland	meat and meat products	mislabelling	minced meat without proper labelling
Ireland	meat and meat products	substitution	meat from species not declared on the label. Lamb was most frequently replaced by meat from other spices and cow was the most commonly undeclared species
United Kingdom	meat and meat products	mislabelling	selling meat labelled as the "Best of British" when actually it was sourced from abroad.
Italy	fish and fish products	mislabelling	found 500 kg of untraceable fish
United Kingdom	meat and meat products	substitution	selling beef as lamb in restaurant

Table 1e An overview of food frauds in 2017 – 2019 in the order in which they were reported.

Country	Commodity	Food fraud	Details
Italy	fish and fish products	mislabelling	restaurants were indicted for selling frozen fish as fresh.
Spain	meat and meat products	substitution	restaurants in Madrid did not correspond to the species indicated on the menu
Italy	fish and fish products	mislabelling	lack of traceability information
Italy	fish and fish products	products not fit for consumption	non-respect of the expiry date and lack of adequate storage conditions
Italy	milk and milk products	substitution	mozzarella, sold in Spain and claimed to be produced using buffalo milk was made mostly with cow milk
Belgium	meat and meat products	mislabelling	meat sold in Belgium under the quality mark Belbeef lacks traceability
Italy	food	substitution	conventional food were labelled as "organic"; in some fields the company produced food respecting the rules of organic production, while on other fields food was produced with the use of pesticides, herbicides, etc.
Italy	milk and milk products	counterfeit	"Grana Padano" and "Parmiggiano" were sold in Canada making fraudulent use of the label "made in Italy".
Italy	milk and milk products	substitution	sale of false mozzarella di bufala DOP
Italy	milk and milk products	substitution	mixing cow and buffalo milk to produce the popular Italian cheese and sold it under the label "mozzarella di bufala".
Italy	meat and meat products	origin masking	sold meat labelled as Italian which rather was the meat of animals grown in other countries, mostly Spain and France
Italy	fish and fish products	artificial enhancement	a large amount of bleach was found in a food production plant
Italy	seafood	products not fit for consumption	octopus, sepia and squid with expiry dates in 2010 were withdrawn from the market
2019			
Malta	meat and meat products	origin masking	Imported live animals were slaughtered but labelled as originating from Malta
Poland	meat and meat products	products not fit for consumption	captured meat from sick cows killed in a Polish slaughterhouse which was not fit for human consumption
United Kingdom	fish and fish products	substitution	fish and chips restaurants sold protected spiny dogfish and some other protected types of shark, which commercialization is forbidden in Europe
Netherland	eggs	products not fit for consumption	eggs contaminated with fipronil
Netherland	eggs	mislabelling	according to the labels the eggs came from a farm that produced "free range" eggs but this information turned out to be false
Italy	eggs	mislabelling	missing traceability information of 4 000 g eggs
Spain	meat and meat products	origin masking	hams which were not designated as PDOs were referred to as PDO hams
Spain	fish and fish products	mislabelling	sale of canned tuna as fresh tuna
Italy	eggs	mislabelling	sale of food commodities fraudulently labeled as organic
Italy	fish and fish products	mislabelling	selling cheaper fish at a much more expensive price to restaurants
Italy	eggs	mislabelling	lacking traceability information

Table 1f An overview of food frauds in 2017 – 2019 in the order in which they were reported.

Italy	food	origin masking	food was labelled as Italian but it came from another country
Italy	food	products not fit for consumption	food that did not meet the required hygienic conditions was on offer
United Kingdom	milk and milk products	substitution	buffalo mozzarella sold in restaurants and supermarkets, was made wholly or partly from cow's milk
Italy	milk and milk products	counterfeit	cheese was labelled as a Protected Geographical Indication (PGI) product without fulfilling the requirements; counterfeited cheese was found
Italy	milk and milk products	products not fit for consumption	the cheese was found after a few months, stored under inappropriate conditions
France	meat and meat products	substitution	meat patties made in Poland contained fat, skin, starch and soya which are not allowed for this type of product
Italy	eggs	products not fit for consumption	the eggs had an extended expiration date in the pack-house
Italy	meat and meat products	mislabelling	hams do not fulfil the requirements to bear the PDO label
Italy	meat and meat products	substitution	hams did not comply with the requirements to bear the PDO labels
Italy	seafood	mislabelling	lacked appropriate information to trace the product
United Kingdom	meat and meat products	mislabelling	some species were declared on the label but in reality were not present in the product, for instance, ham without pork
Belgium	meat and meat products	substitution	meat conventionally produced, and originating from the Netherlands was labelled and sold in Belgium as organic meat
Spain	meat and meat products	products not fit for consumption	meat was contaminated with *Listeria*
Spain	meat and meat products	mislabelling	meat producer sold contaminated meat to a second company, which in turn sold it without indicating on the label the name of the producing company
France	meat and meat products	dilution	fraudulent increase of the weight of chicken meat with water
Spain	meat and meat products	origin masking	meat sold as lamb in Burgos is from other countries
Italy	eggs	mislabelling	organic eggs were from hens in cages
Italy	food	products not fit for consumption	found rotten fish not fit for human consumption
Italy	meat and meat products	counterfeit	butcher sold regular beef as Japanese Kobe beef
Portugal	meat and meat products	products not fit for consumption	meat not fit for human consumption was sold
Portugal	meat and meat products	mislabelling	products that lacked traceability information and did not fulfil administrative requirements
Portugal	meat and meat products	products not fit for consumption	meat was not stored at the right temperature
Portugal	meat and meat products	artificial enhancement	samples contained sulphite, a substance which addition to meat is forbidden
Italy	fish and fish products	mislabelling	fish did not fulfil the legal traceability requirements
Italy	food	mislabelling	some items had a PDO labelling although they did not fulfil the required criteria
France	meat and meat products	products not fit for consumption	rotten meat without traceability
Italy	fish and fish products	mislabelling	sale of food commodities fraudulently labeled as organic

Food or feed which is launched to the market shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.

By the **Regulation (EC) No 178/2002** it is the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing, and distribution.

In samples of eggs, fipronil contamination was reported from several countries. Fipronil is an insecticide of the phenylpyrazoles class and an active ingredient of one of the popular ectoparasiticide veterinary products. Fipronil is also formulated as insect bait for roaches, ants, and termites; as a spray for pets. In humans, poisoning is mainly due to accidental ingestions or suicidal attempts. In agriculture, fipronil is widely used for soil treatment, seed coating, and crop protection **(Ramesh and Milatovic, 2014)**. **EU Regulation (EC) 396/2005** set up the maximum levels for fipronil (0.005 $mg.kg^{-1}$ in chicken eggs) in several raw materials and foods. As consumers pay extra for perceived benefits of free-range eggs, this market sector presents profitable opportunities for producers with expertise in managing hens with enhanced behavioral freedom **(Newberry, 2017)**. According to the labels, some of our samples of eggs came from a farm that produced "free-range" eggs but this information turned out to be false. Several countries reported dyeing low-quality tuna to sell it as fresh fish or case of sulphite addition to meat. Unprocessed foods belong to the food in which the presence of a food dye may not be permitted **(Regulation EC no. 1333/2008)**. Conventional meat and other foods were sold as organic in several cases. Demand for organic meat is partially driven by consumer perceptions that organic foods are more nutritious than non-organic foods **(Średnicka-Tober et al., 2016)**.

The increasing consumer demand for organic products caused the organic food market has expanded in all continents of the world. Organic foods represent a specific segment of the food market **(Kozelová, Vietoris, and Fikselová, 2013b)**.

By our results found at the market, we can agree with the statement of **Vaqué and Vidreras (2018)** that common types of food fraud include the substitution of an ingredient with a similar, cheaper ingredient, the inclusion of undeclared ingredients, adulteration of foods to improve some of their characteristics; non-declaration or false declaration of processes and false declaration of the origin or geographic region of production of a food item.

There were reported several problems regarding the PDO label. EU quality policy aims at protecting the names of specific products to promote their unique characteristics, linked to their geographical origin as well as traditional know-how. By the **JRC Food Fraud Monthly Report (2019)** the inspectors that grant the Prosciutto di Parma and San Daniele PDO labels have resigned the irregularities that have recently been affecting the certification body responsible for the mentioned PDOs. In May 2019, inspectors revealed that 2.5 million hams did not comply with the requirements to bear the PDO labels.

Hypothesis 1 did not assume a link in the country's impact on food fraud. Based on the one-way ANOVA test, this hypothesis was confirmed (p = 0.0067). Hypothesis 2 assumed the influence of the country on which commodities were adulterated. Based on the one-way ANOVA test (, this hypothesis was confirmed (p = 0.000001). Hypothesis 3 did not assume the link among the countries and the years in which the cases were reported. Based on the result of the one-way ANOVA test, this hypothesis was confirmed (p = 0.110). Hypothesis 4 assumed that there was a link between foods that were adulterated and the years that occurred. Based on the result of the one-way ANOVA test, this hypothesis was confirmed (p = 0.0042). Hypothesis 5 assumed that there was a link between the type of counterfeiting and the years that occurred. Based on the result of the one-way ANOVA test, this hypothesis was confirmed (p = 0.009).

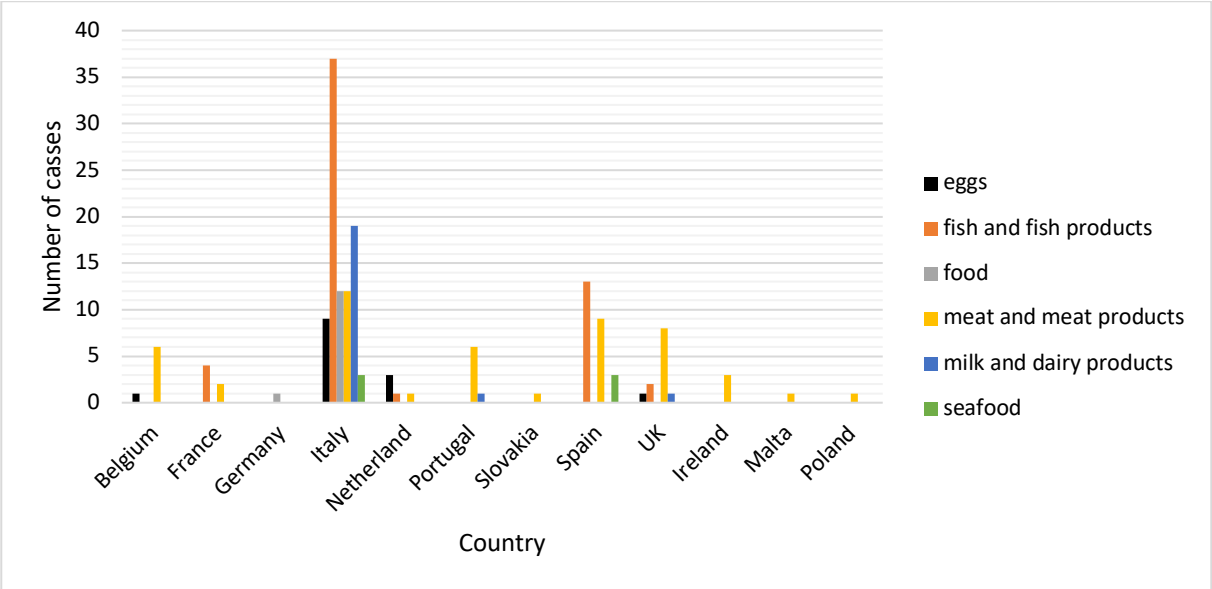

Figure 1 Country in Food Fraud Reports from 2017 to 2019 in Europe.

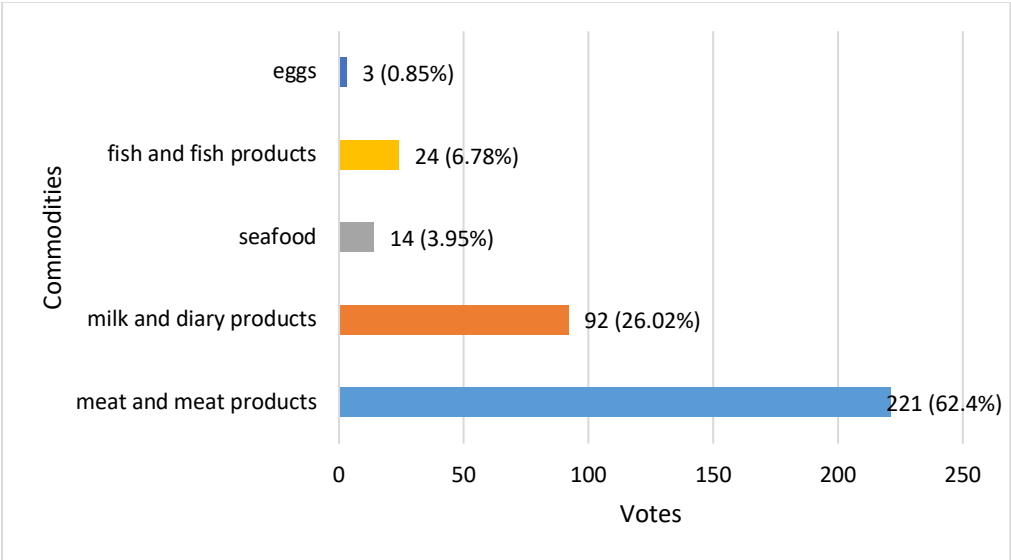

Figure 2 The answer to the question „which commodities are mostly adulterated?".

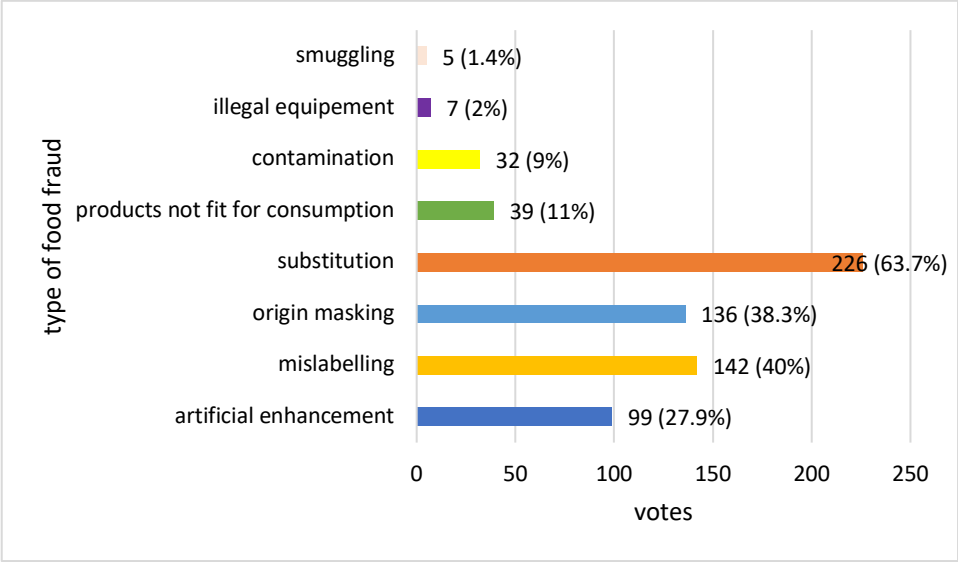

Figure 3 The answer to the question „which of the following causes of food fraud occur most often?".

Analyzes of secondary data from the questionnaire

Food scandals that happened in recent years have increased consumers' risk perceptions of foods and decreased their trust in food safety. A better understanding of consumer trust in food safety can improve the effectiveness of public policy and allows the development of the best practice in risk communication **(Kozelová et al., 2013a)**.

Among 354 respondents who participated in our questionnaire survey, 221 respondents (62.4%) replied to the first question concerning the commodity, that they believe to be the most adulterated is meat and meat products, which is partially in agreement with our results. Some respondents (26.02%) decided on milk and dairy products. Other commodities represented less than 10% (Figure 2).

The safety of milk has always been challenged due to the illegal use of preservatives and adulterants such as hydrogen peroxide, salicylic acid, benzoic acid, water, neutralizers, melamine, and so on **(Parminder and Gandhi, 2015)**.

At the question of which of the following causes of food fraud occur most often, respondents could select two options. 226 people (63.7%) decided for substitution, 142 people (40%) for mislabelling and 136 people (38.3%) for origin masking. Also, these results are partially in agreement with our results. Other types of adulteration received less than 100 votes (Figure 3). The question in which of these countries are food frauds reported mostly, they could also select two options. 310 people (87.6%) decided for Poland, 105 people (29.6%) voted for Slovakia and 43 people (12.1%) for Spain. Other countries received less than 10% (Figure 4). By the **RASFF-Annual report (2018)** there were 47 notifications on *Salmonella* in poultry products originating from Poland, most often (34 notifications) concerning *Salmonella* Enteritidis in fresh poultry. Two operators were identified as recurrent.

EU citizens have the right to be protected from fraudulent practices and to receive accurate information about the food they choose to purchase (**Vaqué and Vidreras, 2018).**

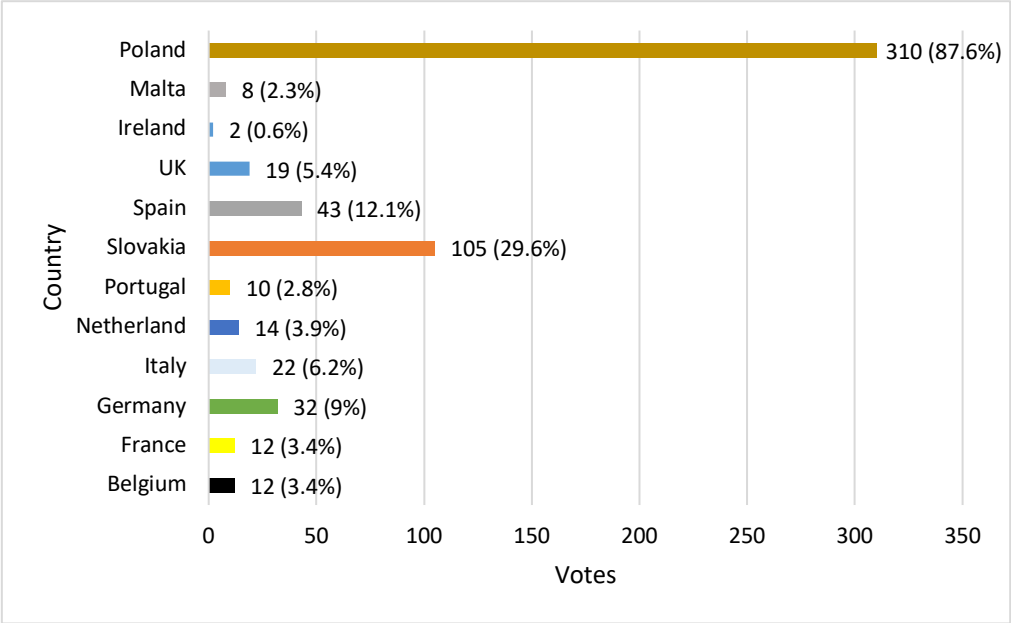

Figure 4 The answer to the question „in which of these countries are food frauds reported mostly?“

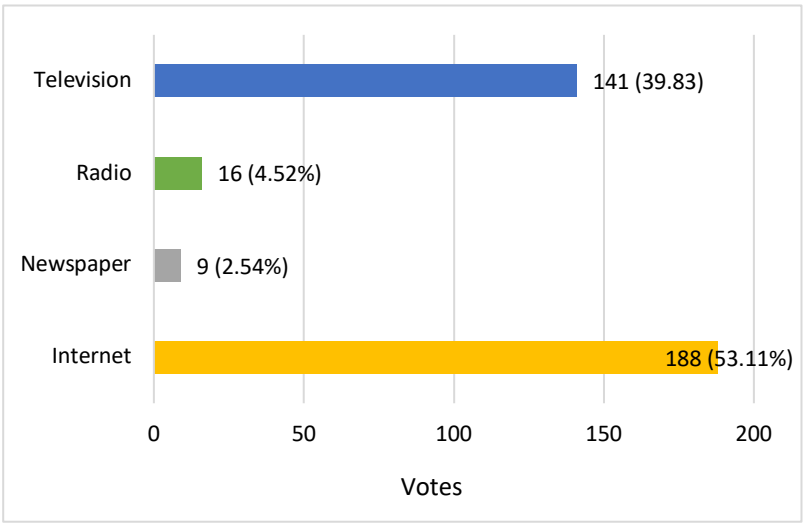

Figure 5 The answer to the question „from which media do you often receive information about food fraud“

So the last question was given about where your information is coming from 188 people (53.11%) select the Internet source and 141 (39.83%) the television source. Radio and newspaper as the source had the lowest number of votes (Figure 5).

CONCLUSION

The present work was focused on the current problems related to food fraud in the European Union countries. We have established hypotheses and confirmed their correctness. Of the total number of 163 cases during the period from 2017 to 2019 registered in KCFFQ, the most reported cases were in Italy and Spain. The most common commodities covered by these reports were fish and their products and meat and meat products. As the most common cause of food fraud was mislabelling. Based on confirmed hypotheses, we conclude that it is not statistically conclusive that the country has an influence on what type of fraud was performed but it has shown the link between the country and the food that has been adulterated. Also, there was no statistically confirmed correlation between countries and years when cases were reported, but a statistically significant correlation between years, commodities and the types of fraud that were reported. The results achieved in the evaluation of the responses from the individual questionnaires and the KCFFQ data indicate some level of information about food fraud topics. These results can be used as a basis for further investigation.

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