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Quality Management in Spice Paprika Production as a Synergy of Internal and External Quality Measures

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***Abstract*—**Spice paprika is a major spice commodity in the European Union (EU), produced locally and imported from non-EU countries, reported not only for chemical and microbiological contamination, but also for fraud. The effective interaction between producers' quality management practices and government and EU activities is described on the example of spice paprika production and control in Hungary, a country of leading spice paprika producer and per capita consumer in Europe. To demonstrate the importance of various contamination factors in the Hungarian production and EU trade of spice paprika, several aspects concerning food safety of this commodity are presented. Alerts in the Rapid Alert System for Food and Feed (RASFF) of the EU between 2005 and 2013, as well as Hungarian state inspection results on spice paprika in 2004 are discussed, and quality non-compliance claims regarding spice paprika among EU member states are summarized in by means of network analysis. Quality assurance measures established along the spice paprika production technology chain at the leading Hungarian spice paprika manufacturer, Kalocsai Fűszerpaprika Zrt. are surveyed with main critical control points identified. The structure and operation of the Hungarian state food safety inspection system is described. Concerted performance of the latter two quality management systems illustrates the effective interaction between internal (manufacturer) and external (state) quality control measures.

***Keywords*—**Spice paprika, quality control, reporting mechanisms, RASFF, vulnerable points, HACCP, BRC Global Standard.

I. Introduction

THE Europe-wide commercial spice distribution network represents an interesting and special segment of the overall food market. One element of this uniqueness is the complexity of the possible routes condiments may enter the food distribution chain that makes it a strategic issue to provide food safety within the spice sector. Another element is that spices are subject to both accidental and deliberate chemical or microbial contamination. To provide and maintain sufficient safety of spice commodities, efficient internal control of processing and external control of finished products marketed is needed.

Food safety is a worldwide priority issue, because due to globalization, food production and processing can cause massive food safety problems. It is necessary to develop and apply new approaches to enhance food safety, including (*i*) introduction and development of food safety programs; (*ii*) analyses of food alert patterns; (*iii*) development of a network analysis tool to aid database interaction; and (*iv*) moves to develop early warning procedures to highlight emerging issues in food safety [1]. Within the legislative food safety framework of the European Union (EU) all food safety issues are the responsibility of the producers, the EU member states and the EU as well. The producers' aim is product safety to provide good market potential for their products and good reputation for their firm and through that assurance of its on-going and stable presence on the food market; while the perspective goal of the member states and the EU is public health and environmental protection on the basis of objective and high quality science-based food and environmental safety risk assessment supported by the most up-to-date and reliable scientific information and data available.

Food safety is being assured in EU member states by both internal and external quality measures. Food producers are required to operate effective and documented quality management systems, as internal measures, with strict specifications for each technological steps and critical control points, inspected and surveyed by the competent food safety authority [2]. In addition, the authorities operate routine screening of food commodities and products both at national and at EU levels as external measures. EU level control of food quality is provided by the RASFF notifying non-compliances with the EU food safety regulations identified in marketed batches and imported consignments [3]. National level control is being executed in Integrated Multiannual National Control Plans by each member state. Reporting mechanisms operated by private quality management systems and required by law are an important basis for tracing of natural and deliberate contamination. The concerted interaction of these internal and external quality control measures acts in synergy to guarantee high level food safety provided for the consumers.

Due to several extensive food scandals and crises at the end of the 20th century, the EU and also Hungary decided to initiate overall changes in food legislation, and establish stricter and more harmonized food safety standards. Although these changes have not fully eliminated contamination cases, yet substantially contributed to the fact that the severe food contamination incidents that occurred in Europe since the seventies (heavy metal contamination in fruits in 1978; wine fraud cases in 1985 and 1986; the bovine spongiform encephalopathy scandal in 1995; dibenzodioxin contamination in chicken and in guar gum in 1999 and in 2007, respectively;

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artificial colorants in spices in 2003; bisphenol A contamination in milk powder in 2008; enterohaemorrhagic *Escherichia coli* in vegetable sprouts in 2011, etc.) [4] remained mostly isolated.

The food control system of the EU, corresponding directives and their legislative background has been established in the 2002-2004 era. The first measure was Regulation 178/2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority (EFSA) and laying down procedures in matters of food safety [5]. This was followed by a package of regulations on hygiene [6]-[8], and then Regulation 882/2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules [2]. The former separated units, independent authorities and institutes adopted the food production, trade and consumption chain approach covering the entire food chain from the farm to the table and enhancing follow-up and prevention. These regulations – to assure high level health and consumer protection – established a new, prevention approach in food policy: Modernization and reformation of laws to standardized and transparent rules, strengthening the control from agricultural production to food consumption, and also promoting an increase in the role of the scientific advisory system. In addition, expert advisory systems operating on market-based mechanisms and supported by the governments in member states also served (and remain serving) as a facilitating element. The aim of both the legislative and the advisory systems was utilization of an integrated, "from farm to fork" approach, covering the overall food chain including feed production, primary food production, processing, storage, transport and trade.

Among the different foodstuffs, spices represent a specific segment, which need to be taken into a special account. In everyday life, all of the meals contain some spice in a smaller or higher amount, which can carry special food safety problems. These possible food safety problems triggered the launch of the EU funded project SPICED – Securing the spices and herbs commodity chain. One of the main principles of the project says that minor components hold major potential to contaminate a wide range of products in a large-scale distribution area [9].

II. Rapid Alert System for Food and Feed

To assure effective enforcement of legal regulations on food safety within the EU the Rapid Alert System for Food and Feed (RASFF) was established in 1979 [10], and its operation is governed by the European Commission and according to individual EU member states the national food safety authorities as focal points or national food safety management authorities [3]. Since its establishment, RASFF operates as a public, reactive, hazard-based reporting system allowing information exchange among EU member states, applicable not only to food contamination, but also to food fraud [11]. Thus, RASFF has been developed not only to identify non-compliances, but also to provide an opportunity to analyze notifications and reach conclusions regarding the efficiency of the operation of the food chain. Several surveys in the scientific literature have dealt with the analysis of RASFF data [12], [13]. The aim of our investigation was to perform a case study on example of RASFF red paprika data in order to understand the paprika turnover on the EU level in their context and give a proposal for the optimization of the practice, as well as to determine the vulnerable points of the paprika supply chain. Spice paprika is the second in the priority list of spices in the EU and the first in Hungary. Thus, according to FAOSTAT and Eurostat data [14], [15], the overall paprika/chili production of the EU ranged between 48.8 and 108.0 thousand metric tons per year between 2002 and 2011, while a half as big again volume, 77.8 to 116.7 thousand metric tons per year was imported during the same period. A visible shift occurs from production to imports: while EU production slightly or substantially exceeded the import level until 2005, an 18.5-113.9% surplus of the imports has been seen ever since, and even after 2011 [16]. Therefore, the European and particularly the Hungarian consumers are subject to substantial exposure to spice paprika, and worldwide product quality has been a factor of increasing significance lately, in food safety as well.

III. Points of Vulnerability

In our interpretation vulnerable points are those physical points of the supply chain and/or product flow, where entering contamination (hazard) according to the risk assessment (probability of hazard *x* exposure *x* severity of the impact) may cause medium or high risk (expected loss), and thus requires the development of preventive and/or eliminating measures. A vulnerability point can be defined not only from the aspect of food safety, but also in relationship to deliberate damages (e.g. terrorist actions, intended malignant acts, sabotage).

In case of spice paprika, mycotoxins, heavy metals, and illegal dye utilization are the main risk sources, but some problems caused by microbial infections and pesticide residues also contribute. Table I shows a prioritized list of different types of food safety non-compliances in spice paprika according to RASFF. Considering the influence of the various contaminants having been reported in RASFF for spice paprika, the largest risk factor occurs to be mycotoxin contamination.

TABLE I
Different Hazards of Paprika According to RASFF

Hazard category	Number of events (2005-2013) [a]
Mycotoxins	260
Non-pathogenic microorganisms	4
Pathogenic microorganism	14
Pesticide residues	23
Heavy metals	3
Adulteration/fraud with Sudan dyes	92

[a] Notifications by product origin, product category, hazard category, identified risk, notifying country, country of origin of the product and world regions are listed in the RASFF Annual Reports [17]-[25].

According to the RASSF system, herbs and spices had the

fourth highest overall incidence level of non-compliances regarding mycotoxins and pathogen microorganisms in 2013 from the 19 product groups. RASFF data show that the number of notifications about mycotoxins shows a decreasing trend both in all spice products and in spice paprika as well [17]-[25]. Nonetheless, health impacts of contamination can be high. Mycotoxin contamination of spices may directly and quickly reach the daily diet of numerous consumers, because spices are used widely not only precooked, but also at the table, although in tiny amounts. Traceability of spice contamination cases is difficult as possible occurrence patterns are very complex. According to the literature [26] herbs and spices are used in an increased amount for the production of processed foods and for ready-to-eat meals. About 55–60% of imported herbs and spices in the EU are used for these production purposes. That is why mycotoxin contamination is a priority concern.

The second biggest hazard factor has been adulteration with Sudan dyes. Sudan dyes, as azo-dyes, particularly Sudan I, are banned in numerous countries, because of their classification as Class 3 genotoxic carcinogens by the International Agency for Research on Cancer [27]. In response, the EU issued Decision 2003/460/EC requiring as a condition of import that all spice chili and its products should be tested for Sudan I [28], and later extended the requirement in Decision 2004/92/EC to include Sudan II, III and IV as well [29]. According to RASFF data, a sharp decrease in numbers of notifications about the prohibited use of dyes in food has been observed since 2003, i.e. 390, 213 and 60 notifications in 2003-2004, 2005, and 2006, respectively. Illegal dyes are still being regularly found since they first emergence in 2003, but at a much lesser frequency than some years before. For this reason, on the basis of the corresponding scientific opinion by EFSA on the toxicology of a number of dyes illegally present in food in the EU [30], Commission Decision 2005/402/EC [31] requiring an analytical report on Sudan dyes for each imported consignment of chili, curry, curcuma or red palm oil was repealed in 2010 and replaced with a 20% sampling at import by addition in the list established by Regulation (EC) 669/2009 [32]. There were still 5 notifications reporting Sudan dyes in spices (1 in palm oil) and 3 reports of rhodamine. Considering the reduced number of non-compliances, Sudan dyes were removed from the listing in Regulation (EC) No 669/2009 from the second trimester of 2012 on. As the problem of spice paprika contamination with Sudan dyes has apparently been solved, emergency measures and obligation of analytical report for each consignment have been overruled; and presently increased control remained only in force.

In addition to the importance of RASFF control, it should be noted, that efficiency of the quality assurance systems at companies (importer/exporter) can also significantly affect food safety. These two effects (official control, company control) cannot be analyzed separately from each other. Both internal and external tools are applied in red paprika production chain to eliminate or decrease the contamination to a minimal level. After Hungary accessed to EU in 2004, the former external quality control system, in which the producers had to provide samples from every batch to the official laboratory, was replaced with a new one, in which the producers' quality management system is responsible for the control. Therefore, all producers are obliged to operate a quality management/assurance and food safety system like Hazard Analysis and Critical Control Points (HACCP), the documentation of which contains all steps of the technology, critical points, where human health risk could occur, self-control points, as well as solutions for possible problems. The authority is entitled to inspect and survey the documentation of self-control. Such reporting mechanisms (including data record systems) for biological and chemical contaminants regulated by law, private quality management systems are required to operate, are similar in EU member states, yet may utilize different strategies in their approach.

IV. An Industry Example – Red Paprika Powder Producer

Kalocsai Fűszerpaprika Zrt., established in the 1930s, is specialized on paprika processing, trading, and conservation of vegetables and fruits. Approximately 70–80% of its production is represented by cultivation, processing and marketing spice paprika. Their production is 1,500-2,000 tons of paprika powder, 1,200 tons of conserved products and 350-400 tons dried products and spice mixtures per year. Kalocsai Fűszerpaprika Zrt. applies BRC Global Standard in its quality assurance.

As indicated in their production technology chart (Fig. 1), they have three critical control points (CCPs) in the production line. CCPs are inspected and surveyed by the competent Hungarian food safety authority. One occurs at the drying step, the second at the microbial decontamination stage, and the third applies when they use imported half-products. Of these CCPs, the drying step requires the highest foresight, because a malfunctioning drying step can impair the sensory and compositional properties of the product. The aim of drying is to reach 6–8% moisture content. Its temperature conditions have an apparent optimum: extensively high temperatures should not be applied to avoid formation of unpleasant aroma, pigment and flavor compounds, while drying at low temperature can lead to poor grinding characteristics. Another CCP in the technology chain is microbial decontamination. A decontamination step needs to be carried out to secure the microbial purity of the product and to avoid contamination of food seasoned with it [33]. Microbial decontamination could be carried out by stream treatment or by irradiation (the maximum allowed radiation dose is 10 kGy [34]. In spite of the high efficacy of microbial decontamination by irradiation, and even though legal regulations allow this technology for decontamination, producers tend to choose stream treatment due to consumer aversion from the food radiation technology. Thus, decontamination at Kalocsai Fűszerpaprika Zrt. is achieved by steam treatment, and technological parameters are surveyed to provide sufficient decrease in the number of cell forming units.

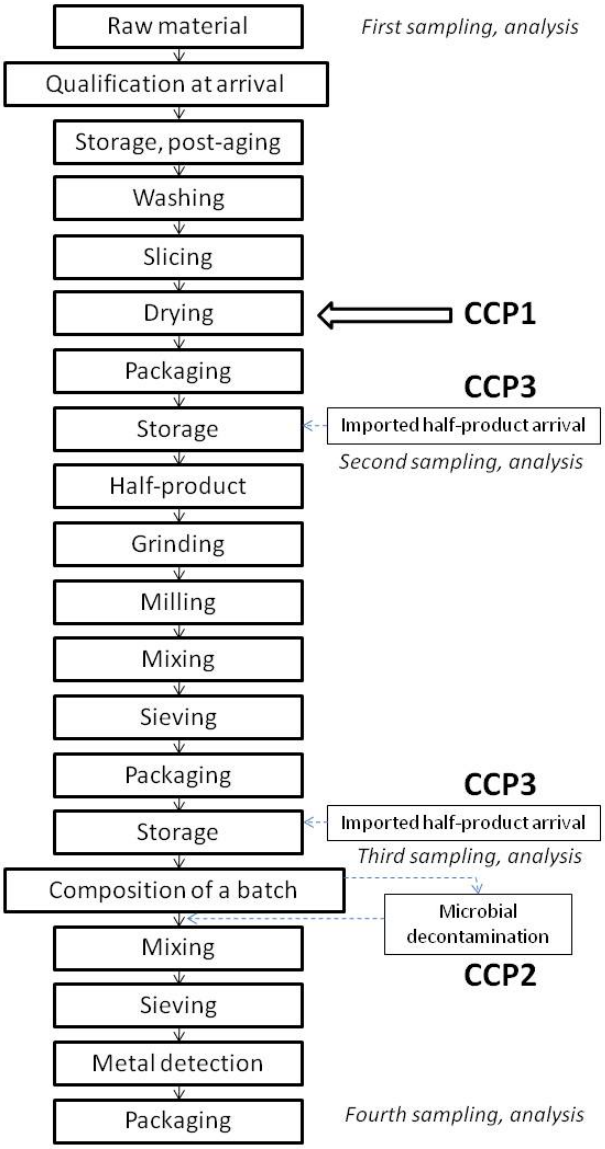

Fig. 1 The red paprika powder production technology chain at Kalocsai Fűszerpaprika Zrt. (Kalocsa, Hungary) operating under the BRC Global Standard quality management system: Critical control points (CCPs) along the technology chain are indicated

In its own analytical laboratories, Kalocsai Fűszerpaprika Zrt. carries out moisture, ash, sand, pigment content, microbiological status (10 parameters) and color determination by the protocol of the American Spice Trade Association (ASTA) [35] at each marked points. Quarterly monitoring contains toxin analyses, pesticide content, illegal pigment content, heavy metal content, *Salmonella*, *Listeria* determination, ethylene oxide content carried out by an accredited laboratory.

V. The National Food Chain Safety Office

Besides quality control obligations by the producers and the applied quality assurance systems, national authorities are also responsible for food safety, and this responsibility is being met by carrying out external control analyses. The current Food Law [36] on the food chain and its official supervision came into force in 2008 in Hungary. This law established a uniform legal background, rules of procedure and control instead of four different former laws (regulating separately food, feed, plant protection, and animal health). After the establishment of the Central Agricultural Office as the main government authority on food safety, this institute had taken several roles, laboratories, labor force from the National Food Safety and Nutritional Science Institute and from the Medical Officer Service. Moreover the Hungarian Food Safety Office also became the connection to RASFF. An additional legal entity, the Hungarian Food Safety Office was assigned to prepare and implement annual food safety control plans, to communicate with the EU central organizations, and to serve as a focal point to EFSA.

In the scope of a centralization measure, these two offices were merged into a single organization, the National Food Chain Safety Office (NFCSO) in 2012, within which the former Hungarian Food Safety Office continued operating as the Food Safety Risk Assessment Directorate. The current structure of the National Food Chain Supervisory System in Hungary is depicted on Fig. 2. As seen, the current structure of NFCSO as the food chain supervision authority operates at three levels: (*i*) Country level: National Food Chain Safety Office; (*ii*) County level: County Government Offices and Directorates – Food Safety and Animal Health Directorate, – Plant Protection and Soil Conservation Directorate; (*iii*) District level: district offices (departments of the Food Safety and Animal Health Directorate).

According to Regulation No. 882/2004 [2] EU Member States are required to prepare their own Integrated Multiannual National Control Plan (MANCP). This regulation defines that risk-based official controls should be carried out. The national authority should define exact risks and assess the seriousness and probability of their occurrence. Guidelines of the Food and Agricultural Organization and the World Health Organization of the United Nations advise risk-based planning. Beside risk assessment, other factors also affect the planning, e.g. EFSA and EU guidelines, RASFF data, available tools and solutions, the extent of the economic effects of the risks, as well as ethical and political considerations. In the annual plan, member states should specify their risk priorities, product groups, sample numbers, parameters to be measured and also a financial plan. After reconsideration, the plan of the official control sampling is assigned to months and counties. One part of the official control is *ad hoc* sampling, but most of it is determined control according to known data. Official control analyses are carried out by the laboratories of NFCSO and the National Reference Laboratories (NRLs).

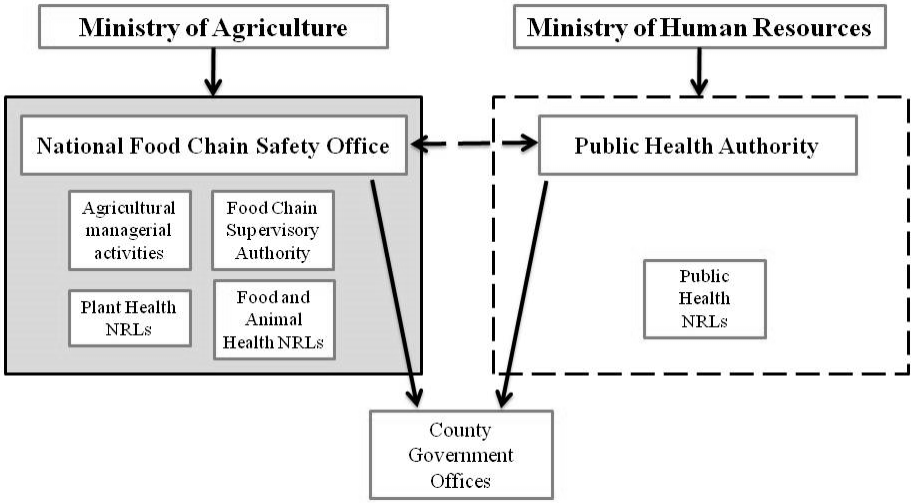

Fig. 2 The National Food Chain Supervisory System in Hungary [37]. In addition to serving as supervisory authorities, the system operates National Reference Laboratories (NRLs)

VI. Official Control of Red Paprika Powders in Hungary, December 2014

Within the MANCP campaign in 2014, NFCSO carried out a systematic survey on 46 spice paprika samples, the inspection including both chemical analyses for contaminants and for compositional evaluation and popularity assessment. Samples were taken from commercial spice paprika products from shelves of supermarkets and grocery stores in Hungary.

In the scope of chemical analyses, natural pigment, moisture, total ash, acid insoluble ash, as well as capsaicinoid content were determined. In case of two powders, total ash content was higher than the upper limit value, which shows the presence of contaminants and vegetal parts with higher fiber content that should have been discarded prior to processing. In case of three samples, natural pigment content was under the minimum limit, and for two samples, the moisture content was higher than the limit allowed. Another two products' capsaicinoid content did not fulfill the requirements. As for mycotoxin (aflatoxin B_1 and total aflatoxin (the sum of aflatoxin B_1, B_2, G_1 and G_2), as well as ochratoxin A) content, pesticide residues and unauthorized or banned pigment (Para Red, Sudan I, II, III and IV, Sudan Orange G) content and irradiation, every product met the requirements.

As for popularity, four groups (delicate, noble sweet, special quality, pungent) were designated, and samples were categorized within these four groups. The traditional Hungarian red paprika powders were found to be top ranked. In popularity ranking, experts, laymen and civilians evaluated the products in sensory analysis according to color, taste and aroma. Evaluators ranked the products with scores from 1 to 5 regarding the above characteristics.

Proper product notation on the package labels, containing all legally required information to the consumer, was also inspected. The survey revealed incomplete label information in case of a few products. Most common missing information included the name or address of the producer, or accurate indication of the quality group [38].

VII. Hungary in RASFF

Mapping non-compliance cases and alerts among EU countries within RASFF is an informative tool also in identifying the sources of non-compliances on the EU markets. It has to be noted, however, that such claims may be related to products originated from outside the EU, reaching the EU market by imports or blending into EU spice paprika products. Fig. 3 summarizes and illustrates RASFF notifications on mycotoxins in spice paprika within the EU between 2005 and 2013. There were 14 cases with the 'via' country identified as well. These cases are also illustrated, because a more accurate picture can be obtained in this way about the control system within the EU. The network map shows that most non-compliance cases were identified in relation to Spain, and the main notifiers are Germany and the Netherlands. Within the EU in terms of paprika turnover Spain is considered as a vulnerable point. Hungary was notifier in two cases towards Slovakia and Spain, and it was consigner in three cases in relation to Denmark, Spain and Slovakia.

VIII. Interaction – Cooperation

Authority supervision attempts to maintain an ongoing interaction between the obligatory private management systems and the food safety inspection network. Thus, NFSCO compiles databases from the results of its own inspections, with data from producers' technology parameter determinations also incorporated. Analysis of these databases provides information for government survey strategies and supports food safety provisions.

Joint ring trials, among private quality management laboratories and NRLs have been organized. These exercises

allow proficiency testing among private and government inspection facilities, and to improve the analytical goodness of official determinations both in the private and government sectors.

Mycotoxin analysis data, for example, receive higher priority in the national control plan in periods with moist weather conditions. Reported mycotoxin contamination cases (e.g. in 2004, when mycotoxins from *Aspergillus* species were detected substantially above the official maximum residue level in 12 cases out of 73 inspected products) resulted in more severe quality requirements that led not only to higher level quality management protocols at the manufacturers, but also to better communication between the private and government sectors. For example, producers introduced stricter quality control determinations, often with accredited external analytical service providers, for each consignment of imported paprika commodities, even if the shipment arrived with quality certificate from the supplier. In cases, when differences occur in the contamination status declared by the supplier and determined by the Hungarian manufacturer, the latter informs NFCSO, and the documentation is entered into the contamination database. In addition, accredited sampling and analytical determinations have received increased priority in the assessment of the contamination status. These concerted efforts have led to an effective assurance of the quality of spice paprika products on the domestic and foreign trade market, as seen from the results of the 2004 spice paprika survey by NCFSO (*see before*).

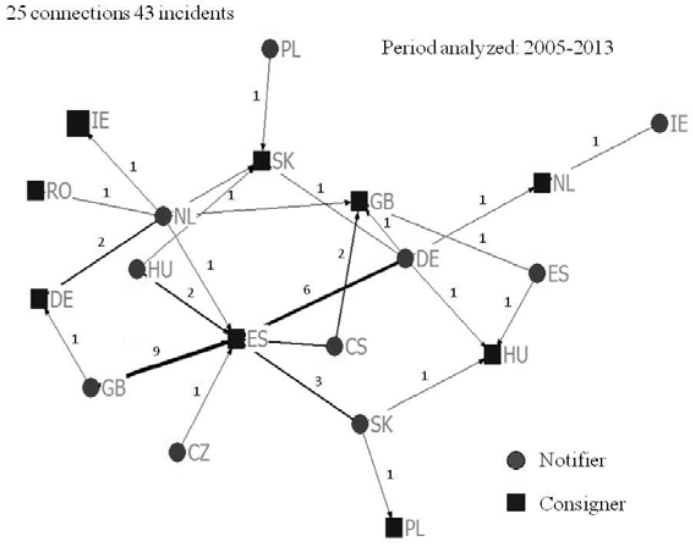

Fig. 3 RASFF notifications about mycotoxin contaminations in spice paprika between 2005 and 2013 with respect to turnover within the EU. Squares and circles designate consigner and notifier countries, respectively, thicknesses of the connecting lines are proportional with notification cases. The spice paprika notification network occurs to be dominated by an apparent GB – ES – DE axis.

IX. Conclusion

Red paprika is traditionally one of the most important Hungarian spices, and despite its small amount of utilization it should be taken into account as a possible health risk factor. Mycotoxin and heavy metal contamination, as well as the presence of forbidden dyes presents high health hazard. The producers' quality management system and quality control by the food safety authority, acting in concert, aim to guarantee good production practice and to support efforts to preserve the outstanding reputation and purity of Hungarian red paprika. Data on alerts in RASFF and the results of the analyses by the Hungarian authority indicate that both the internal (the producers' side) and external (the authority side) complement to each other and fulfill their obligations.

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