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ANALYSIS OF *SALMONELLA* SPP DETECTIONS IN EUROPEAN UNION COUNTRIES ACCORDING TO RASFF DATABASE

S. Ye. Smajhel[1], N. B. Shadrova[2]

[1] Leading Veterinarian, FGBI "ARRIAH" Branch in the Republic of Crimea, Simferopol, Russia, *e-mail: shmaihel@arriah.ru*

[2] Head of Laboratory, Candidate of Science (Biology), FGBI "ARRIAH", Vladimir, Russia, *e-mail: shadrova@arriah.ru*

SUMMARY

Official data of RASFF (Rapid Alert System for Food and Feed) database on detection of *Salmonella* spp. in animal and plant raw materials in 2010–2015 are demonstrated. Total of 2,651 notifications of *Salmonella* spp. detection were reported by RASFF member countries. The majority of such notifications are associated with contamination of poultry meat and poultry products, feed, fruits and vegetables. *Salmonella* can survive in food for a long time (up to 6 months). The cause of salmonellosis in humans mostly involves consumption of raw or insufficiently heat-treated eggs, meat and milk products. Regulation (EU) No. 142/2011 prescribes a requirement, which the heat-treated and processed food products shall comply with, i.e. absence of *Salmonella* in 25 g of the product. Analysis of RASFF data for 2010–2015 demonstrated annual increase of *Salmonella* spp. detections. The most frequently occurring is ***Salmonella enterica***. Over the above mentioned period there were notifications of 154 *Salmonella* serovars, the overwhelming serovars include *S. enterica* – 32.4%; *Salmonella* spp. – 18.8%; *S. enteritidis* – 6.3%; *S. typhimurium* – 4.6%, *S. Agona* – 2.6%; *S. Lexington* – 1.4%. ***Salmonella*** spp. were detected in poultry meat (19.5%), in feed for dogs and cats (5.6%), in pork (3.7%), in fishmeal (5.1%). During the period from 2010 to 2014, the increase of *Salmonella* notifications in plant feed was reported. Over 2010–2015, RASFF reported of 42 salmonellosis outbreaks that resulted in 1,586 diseased humans.

Key words: *Salmonella*, animal and plant raw materials, RASFF, European Union, salmonellosis outbreaks.

INTRODUCTION

Salmonella is a genus of non-spore- or capsule-forming rod-shaped gram-negative bacteria of *Enterobacteriaceae* family. *Salmonella* demonstrate a significantly high degree of resistance to different environmental factors. Boiling kills *Salmonella* instantly, but at low temperatures (–20 °C) they remain viable for a long time. *Salmonella* persists in the environmental media: in surface and potable water for 11–120 days, in seawater for 15–27 days, in soil for 1–9 months, in dust for 80–547 days, in sausage for 60–130 days, in frozen meat for 6–13 months, in eggs for up to 13 months, in egg powder for up to 9 months, on fruits and vegetables for 0.5–2.5 months. *Salmonella typhimurium* are the most stable remaining viable on cloth and paper for up to one year [4].

The majority of *Salmonella* not only survive in food (in milk for 2–40 days, in kefir for about 30 days, in smoked food for 4–6 months), but replicate accumulating endotoxins. According to the O-antigen structure the *Salmonella* are subdivided into groups A, B, C, D, E, etc.; according to the flagellar (H) antigen – into serovars. Over 700 serovars were isolated from humans [13].

Current classification subdivides *Salmonella* genus into two species – *S. enterica* and *S. bongori*, *S. enterica* are subdivided into several subspecies.

Subdivision into subspecies has definite epidemiological implication as the basic natural reservoir of *Salmonella* subspecies 1 and 2 involves warm-blooded animals, and cold-blooded animals and environment serve as reservoirs of other *Salmonella* subtypes (IIIa, IIIb, IV, VI and *S. bongori* (V)). Current Kauffman-White scheme numbers 2,579 serological variants of *Salmonella* [5].

Many *Salmonella enterica* serotypes are agents of human diseases including typhoid fever, paratyphoid, salmonellosis. Salmonella of *Salmonella bongori* subspecies are not pathogenic for humans [14].

Salmonellosis is most frequently caused by *Salmonella*-containing eggs (up to 90% of salmonellosis cases are associated with the consumption of raw or insufficiently heat-treated eggs), meat and milk products and plant

products. Animals (ducks, chickens, cattle, pigs and sheep) serve as a natural *Salmonella* reservoir. *Salmonella* are often introduced into food due the non-correct cooking or poor sanitation during cooking [14].

Poultry meat is contaminated with microorganisms ante mortem, after slaughter and during treatment at scalding, defeathering and cooling [3].

According to the World Health Organization, *Enteritidis* and *Typhimurium* Salmonella enterica serotypes are the most significant Salmonella serotypes, which are transmitted from animals to humans in the majority of the regions of the world [12].

The work was aimed at the analysis of *Salmonella* detections in the European Union (EU) countries according to the data of RASFF database for 2010–2015.

ANIMAL AND PLANT RAW MATERIAL SAFETY AND QUALITY CONTROL IN THE EUROPEAN UNION COUNTRIES

1. EU Rapid Alert System for Food and Feed (RASFF) was created in 1979 in order to provide the food safety and quality control authorities with efficient tool for rapid exchange of information in case of detection of food products hazardous for human and animal health.

The membership in the system is shared by all EU countries, Norway, Liechtenstein, Iceland, Switzerland and European Food Safety Authority (EFSA). RASFF member-country, on whose territory the EU legally regulated microorganisms or analytes are detected, shall enter into RASFF the required data on non-compliant product and measures taken for removal of risks due to its consumption. Such rapid exchange of information allows for real-time assessment by all RASFF members of the need for urgent measures including recall, withdrawal and destruction of the concerned product. Authorized bodies of RASFF member-countries are responsible for taking necessary urgent measures including reporting direct information to the community, product withdrawal from the market and on-site control [17].

About half of the RASFF notifications are related to food control on the outer EU borders, in entry points and border inspection posts. Notifications on non-compliant products can also be made as a result of inspections by the control authorities and due to food poisoning incidents.

The EU food safety and quality control legislation is based on EU Regulations No. 178/2002 and No. 882/2004.

EU Regulation No. 178/2002 prescribes general principles of the EU food law and comprises all stages of food production and processing within the food chain "from farm to fork". The Regulation additionally establishes and defines the responsibilities of the European Food Safety Authority (EFSA) and introduces the Rapid Alert System for Food and Feed (RASFF).

EU Regulation No. 882/2004 established general principles of the official control aimed at the assurance of compliance with food and feed law. Therewith, along with the introduction of relative reporting the EU countries imposed the development of multiannual national food safety control plan (Multi Annual National Control Plan) [1].

Since the EU legislation does not prescribe any microbiological criteria as for *Salmonella* level in raw materials, RASFF notifications are based on national criteria or on case-by-case risk assessment.

The requirement of zero *Salmonella* in 25 g of the product is prescribed in Regulation (EU) No. 142/2011, and following the Council Directive 94/65/EC the minced meat is included in the list of products subject to *Salmonella* control.

Product sampling for *Salmonella* testing shall be performed according to EN/ISO 6579 requirements.

In case any disputes over the microbiological test results arise between the countries, ISO 6579:2002 Microbiology of food and animal feeding stuffs – Horizontal method for the detection of *Salmonella* spp. shall be considered as a reference method. This international standard is applicable to food products and prescribes the method for the detection of *Salmonella* spp. including *S. Typhi* and *S. Paratyphi* in the products at definite weight or volume [2, 11].

According to Regulation (EU) No. 2160/2003, specific infection control measures are prescribed in case of detection of *S. enteritidis* or *S. typhimurium* serological types in the collected samples [10].

2. Detections of Salmonella spp. in the European Union countries in 2010–2015. According to RASFF data, over the above mentioned period 2,651 notifications of *Salmonella* spp. detection was reported by the EU countries. *Salmonella* spp. were detected in the following products: poultry meat and poultry meat products – 23.4%, feed materials – 22.9%, fruits and vegetables – 13.8%, meat and meat products (other than poultry meat) – 11.2%, herbs and spices – 7.5%, nuts, nut products and seeds – 6.5%, pet food – 5.4%, bivalve mollusks – 1.6%, milk and milk products – 1.2%, eggs and egg products – 1.0%, fish and fish products – 0.7%, crustaceans – 0.7%, cephalopods – 0.6%, dietetic food, food supplements, fortified food – 0.5%, animal by-products – 0.5%, cereal and bakery products – 0.4%, cocoa and cocoa preparations, tea and coffee – 0.3%, compound feed – 0.3%, confectionery – 0.3%, other food products/mixed – 0,3%, food additives and flavourings – 0.2%, fats and oils – 0.1%, feed additives – 0.1%, premixtures – 0.1%, gastropods – 0.1%, ice and desserts – 0.1%, prepared dishes and snacks – 0.1%, soups, broths, sauces, condiments – 0.1% (see the Table).

In 2010, twenty-seven EU countries made 346 RASFF notifications on *Salmonella* spp. detection, out of which the border control authorities reported 108 cases and 284 cases were detected during the official control in the market. Therewith, 81 notifications (34%) were associated with internal controls.

In 2011, the number of *Salmonella* notifications increased up to 402. It is worth mentioning that 26 out of 5 notifications were associated with herbs and spices originated from Vietnam, while in 2010 there was only one such notification.

In 2013, the number of notifications increased up to 485, and in 2014 – up to 477. The Netherlands made 49 notifications about Brazil-originated poultry meat products, which failed border inspections.

In 2015, 522 notifications of *Salmonella* spp. detection were published in RASFF (Fig. 1).

Detection of Salmonella spp. in products of animal origin. In 2010–2015, RASFF member countries submitted 1,486 notifications of *Salmonella* spp. detection in raw materials and feed of animal origin.

According to RASFF data, in 2010 *Salmonella* were most often detected in poultry meat and in feed. The poor quality products originated from Germany, Turkey and India. In 70 cases *S.* enterica subsp. *enterica* was detected.

Thirty-two *Salmonella* serovars were detected in feed; in meat and meat products (including poultry ones) – 32; in bivalve mollusks – 1; in eggs – 5; in fish and fish products – 5; in milk and milk products – 4; in gastropods – 1; in fats – 2; in dietetic products, food supplements, fortified products – 3; in crustaceans and products thereof – 4; in animal by-products – 1 (see Fig. 2).

In 2011, *S. enterica* was detected in the majority of food categories and feed. As compared to 2010, the *Salmonella* serovar diversity increased along with the number of its notifications: bivalve mollusks – 4 *Salmonella* serovars according to 6 notifications; in feed – 24; in meat – 12; in poultry meat – 17; in eggs and egg products – 3; in fish and fish products – 2; in milk and dairy

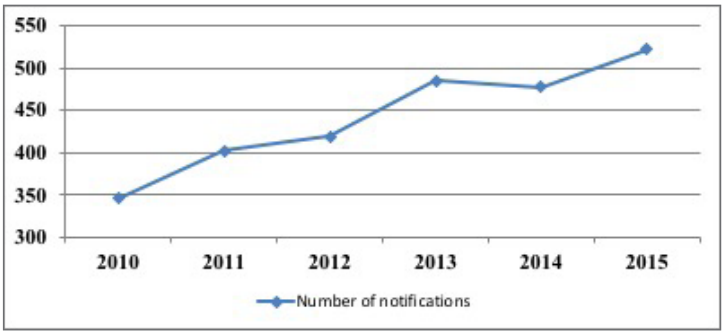


Fig. 1. Increase in RASFF notifications of Salmonella spp. detection, 2010–2015

Table
***Salmonella* spp. distribution by type of products**

Products	2010	2011	2012	2013	2014	2015	Total
Poultry meat	53	42	54	171	152	149	621
Feed material	83	102	106	112	115	88	606
Fruits and vegetables	5	100	70	58	37	95	365
Meat and meat products (other than poultry meat)	66	37	61	53	37	44	298
Herbs and spices	33	55	32	24	29	25	198
Nuts, nut products and seeds	22	13	21	12	30	73	171
Pet food	36	24	19	17	29	19	144
Bivalve mollusks	3	6	4	17	9	4	43
Milk and milk products	4	4	4	3	8	8	31
Eggs and egg products	6	6	6	2	5	3	28
Fish and fish products	11	2	1	3	1	1	19
Crustaceans and products thereof	5	3	2	1	3	5	19
Cephalopods and products thereof	–	1	14	–	–	–	15
Dietetic products, food supplements, fortified food	3	–	–	1	4	5	13
Animal by-products	2	–	7	–	4	–	13
Cereal and bakery products	1	1	3	1	2	2	10
Prepared dishes and snacks	–	–	2	2	5	–	9
Cocoa and cocoa preparations, tea, coffee	3	1	2	–	1	1	8
Other food products	–	–	6	2	–	–	8
Compound feed	1	3	–	2	1	–	7
Confectionary	5	–	–	1	2	–	8
Food additive and flavourings	1	–	1	2	–	–	4
Fats and oils	2	–	–	–	1	–	3
Gastropods	1	–	1	–	1	–	3
Feed additives	–	–	1	–	1	–	2
Premixtures	-	1	1	-	-	-	2
Soups, broths, sauces and condiments	-	1	1	-	-	-	2
Ice and desserts	-	-	-	1	-		1
Total	346	402	419	485	477	522	2651

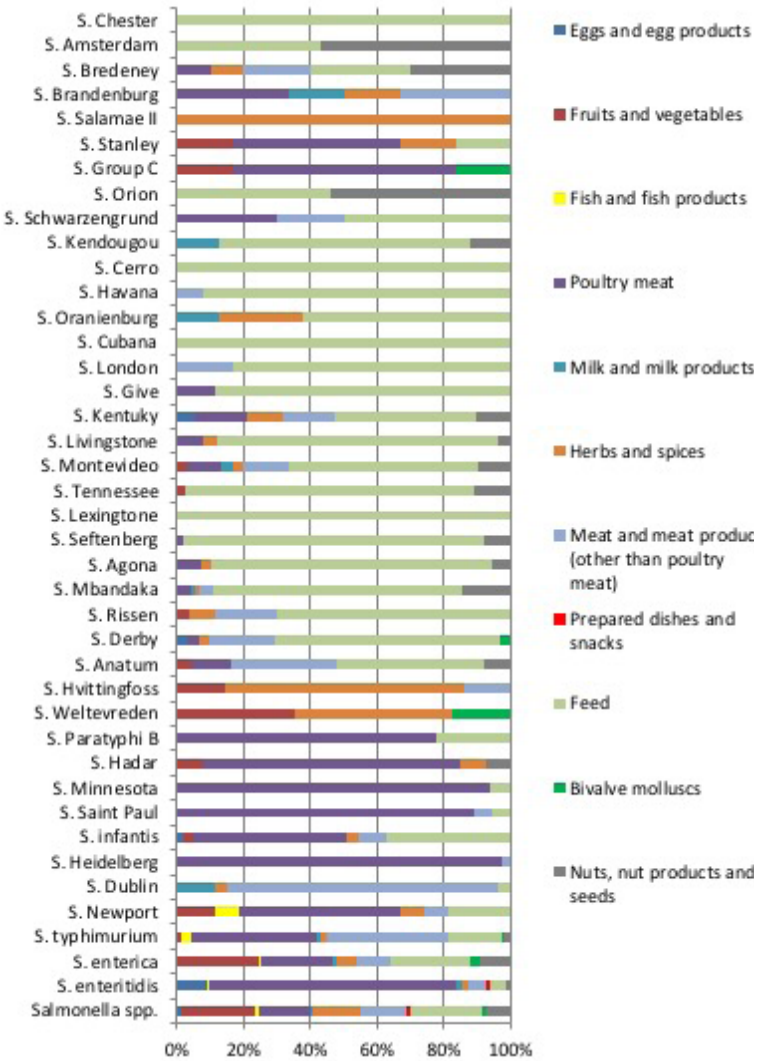
products – 3; in crustaceans and products thereof – 2; in frozen squids – 1.

In 2012, *S. enterica* was detected in all consignments of cephalopods originated from Indonesia. The highest serovar diversity was reported in feed (18 serovars), meat (other than poultry meat) (11 serovars), poultry meat (12 serovars).

By contrast to 2010–2012, in 2013 the notable increase of *S. enterica* detections (from 13 to 17 notifications) and *Salmonella* serovar diversity (from 5 to 8 serotypes) was reported in frozen bivalve mollusks (originating country – Vietnam). As compared to 2012, the number of *Salmonella* detections in meat (other than poultry meat) decreased, and it increased in poultry meat up to 171 (the highest level over 2010–2105). Herewith, in 29 cases *S. Heidelberg* was detected and 28 cases – *S. enteritidis*. The majority of semi-finished products and fresh poultry meat originated from Brazil. Sixteen *Salmonella* serovars were detected in feed; in meat (other than poultry meat) – 12; in poultry meat – 26; in eggs and egg products – 2; in fish and fish products – 3; in raw milk and milk products – 2; in crustaceans – 2; in insect pupae – 1; in ice-cream – 1.

According to RASFF data, in 2014 *Salmonella* were most often detected in poultry meat and feed. It is expected that while consuming *Salmonella* contaminated feed the poultry become diseased and remain salmonellosis carrier. However, RASFF data analysis demonstrated that serotypes most frequently occurring in feed (*S. Agona, S. Mbandaka*, *S. Livingstone*) are scarce in poultry meat. *S. enteritidis* and *S. typhimurium* are often reported in poultry meat. In 2014, twenty-seven *Salmonella* serovars were detected in feed; in meat (other than poultry meat) – 15; in poultry meat – 17; in fats – 1; in bivalve mollusks – 2; in eggs and egg products – 2; in fish and fish products – 1; in milk and milk products – 6; in gastropods – 1; in crustaceans and products thereof – 2; in by-products – 4.

Fig. 2. RASFF recorded Salmonella serotypes, 2010–2015



In contrast to 2014, the number of *Salmonella* detections in pet food and feed of animal origin decreased in 2015 from 29 to 19 notifications and from 56 to 38 notifications, respectively. Five notifications of *Salmonella* in crustaceans from Vietnam demonstrate that all of them belonged to *S. enterica* serotypes. Fifty-eight notifications of *Salmonella* spp. detections in poultry meat were reported from the Netherlands, and *S. enterica* serotypes prevailed. Brazil, Poland, Thailand, Germany, Belgium and France are the first in the list of manufacture countries. Over the year, twenty-one *Salmonella* serovars were detected in feed; in meat – 24; in bivalve mollusks – 1; in eggs and egg products – 3; in fish and fish products – 1; in milk and milk products – 5; in crustaceans – 5.

The feed materials (meat-and-bone meal, feather meal, fishmeal, processed ruminant protein) and pet food are the key sources of *Salmonella* spp. The *Salmonella* serotype diversity in such products prevails over the serotype diversity reported in other categories. Moreover, *Salmonella* serovars detected in feed materials were slightly different from the ones detected in pet food.

In 2010–2015, there were 118 notifications of *Salmonella* detection in fishmeal including 34 notifications about the meal manufactured in Mauritania, 27 in Morocco, 18 in Chili, 11 in Peru, 10 in the USA, 6 in Denmark, etc. The majority of the notifications of *Salmonella* detection in the processed ruminant proteins are associated with the products manufactured in the Netherlands, France, Spain, Germany, Mexico; in pet food – products manufactured in India, Poland, Brazil, Mexico, Germany.

According to the Rosselkhoznadzor reports, Brazil implements National Program of Pathogens Reduction (*Salmonella* spp. in poultry and turkey carcasses). However, the on-site inspections of the poultry slaughterhouses demonstrated major violations during meat product storage and labelling, non-compliances with general hygiene requirements, lack of adequate control of the personnel's compliance with general animal health requirements during movements between clean and dirty areas. The same was reported at Vietnamese establishments manufacturing frozen shrimps and seafood. In case of *Salmonella* positive test results neither state veterinary service nor the management of the establishment take any response measures. Insufficient control over the sanitation on the production facilities and along the production flow by the competent authorities and relative on-site service is reported. The similar situation is in Vietnam, no national monitoring of seafood for *Salmonella* is performed [6–9].

Detection of Salmonella spp. in plant products. In 2010–2015, RASFF members made 1,125 notifications of *Salmonella* spp. in food and feed of plant origin.

Following repeated notifications of *Salmonella* in herbs from Thailand, a 10% mandatory sampling was set up in October 2010 for consignments of mint, basil and

coriander leaves entering the EU by way of Regulation (EC) No 669/2009 [20]. Over all of 2010, there have been 19 notifications about *Salmonella* in various herbs from Thailand.

Half of the notifications of *Salmonella* in nuts, nut products and seeds were associated with sesame samples from Turkey. Total of 24 *Salmonella* serovars were detected in feed of plant origin; in herbs and spices – 14; in fruits and vegetables – 5; in nuts and seeds – 8; in cocoa, cocoa preparations, coffee and tea – 2.

As compared to 2010, in 2011 the number of notifications for some product categories increased as well as *Salmonella* serotype diversity in these products: in fruits and vegetables – 11 ; in herbs and spices – 24; in cocoa, cocoa preparations, coffee and tea – 1; in nuts and seeds – 3; in feed of plant origin – 27; in premixtures – 1. *Salmonella* contamination of herbs and spices was reported by 55 notifications, out of which 20 notifications (36%) were related to products from Vietnam.

In 2012, just as in 2011, the majority of *S. enterica* detections in Bangladesh manufactured paan leaves (betel leaves) were notified by the United Kingdom. *S. enterica* was also reported in spices from Turkey, Germany and India. Nine *Salmonella* serovars were detected in fruits and vegetables; in herbs and spices – 16; in cocoa, cocoa preparations, coffee and tea – 1; in nuts and seeds – 11; in feed of plant origin – 25; in premixtures – 1; in feed additives – 1.

Four out of five plant product notifications reported *S. enterica* in tahini from Syria and one notification (guar gum powder) reported *S. enterica* subsp. *salamae* II.

In 2013, the majority of *Salmonella* detections in fruits and vegetable were notified by the United Kingdom. *S. enterica* serotype was still detected in paan leaves supplied from Bangladesh, India and Thailand; and in feed originating from the Netherlands, Italy and Argentina.

Thirty-three *Salmonella* serovars were detected in plant feed; ten serovars were detected in fruits and vegetables; in herbs and spices – 12; in nuts and seeds – 7; in dietetic food, food supplements, fortified food – 1; in soy protein products – 1.

In 2014, twenty-three notifications of *Salmonella* detection in sesame from India were reported. During the period from 2010 to 2014, the number of notifications of *Salmonella* spp. detections in plant feed annually increased, mostly in rape and rape flour, soy and soy flour from Brazil, Argentine, Germany, the Netherlands and Italy.

Twenty-nine *Salmonella* serovars were detected in feed of plant origin; in fruits and vegetables – 8; in cocoa, cocoa preparations, coffee and tea – 1; in feed additive – 1; in pet food – 1; in herbs and spices – 11; in dietetic food, food supplements, fortified food – 3; in nuts – 13.

In 2015, the number of notifications of *Salmonella* detections in feed decreased, but it increased for betel leaves from India (78 notifications) and sesame seeds from India (64 notifications). That was due to the increase of the total number of notifications. *S. enterica* was detected in the infant formula manufactured in the Netherlands that was notified by Germany. There were 24 notifications of *Salmonella* detected on the Latvian border in rape cakes exported from Belarus. Eighteen *Salmonella* serovars were detected in plant feed; in fruits and vegetables – 12; in cocoa, cocoa preparations, coffee and tea – 1; in dietetic foods, food supplements, fortified foods – 4; in herbs and spices – 18; in nuts and seeds – 23.

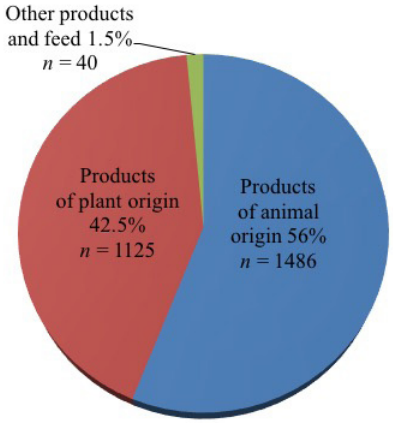


Fig. 3. Salmonella spp. in food and feed

In 2013–2015, *S. Rissen* and *S. Aberdeen* were detected in China-originated Chlorella and *S. enterica* was reported in horseradish tree powder manufactured in India.

In addition, RASFF includes information of *Salmonella* contamination of the following plant products: pine nut kernels, hazelnuts, dried coconut, cardamom, garlic, poppy, chickpeas, peanut butter, flour and melon seeds, sunflower seeds, almond nuts, tea, muesli with nuts, curry, caraway seeds, oregano, black pepper, parsley, bay leaves, chili, and coriander.

Salmonella spp. detection in other (compound) food and feed. In 2010–2015 RASFF member-countries submitted 40 notifications of *Salmonella* spp. detections in the following products: confectionery – 8; cereals and bakery products – 10; compound feed – 7; food supplements and flavourings – 4; prepared dishes and snacks – 9; soups, broths, sauces and condiments – 2. This category of products includes biscuit, muesli with nuts, pasta, buckwheat flour, cookies, tofu flour, chocolate, halva with pistachios, chocolate bars with hazelnuts and coconut, salad dressings and salads with chicken meat and ham, vegetable rolls, galactooligosaccharide and maltodextrin.

S. enterica, *S. Mbandaka*, *S. enteritidis*, *S. infantis* serotypes prevailed. The majority of the notifications were reported from Belgium, Germany and France, and poor quality products originated from Poland, Belgium, France, the Netherlands and Germany.

The proportion of *Salmonella* spp. in animal and plant products as well as in other (compound) food and feed in 2010–2015 is demonstrated in Figure 3.

3. Salmonella spp.-associated food poisonings in the European Union (Fig. 4). In 2010, six cases of food poisoning were reported that were mostly associated with sausage consumption in the following EU countries: Italy, Germany, France, Denmark, Luxembourg. As a result, 663 humans were affected. These data are related only to the incidents notified to RASFF but they do not comprise all food poisoning cases occurred in the EU countries.

A retrospective study carried out of the collective foodborne outbreak in four schools in France enabled isolation of *Salmonella* from 554 out of the 1,559 exposed individuals. The presence of *Salmonella* was confirmed in 13 hamburgers sampled [20].

In 2011, seven food-poisoning cases were notified to RASFF. The cases were associated with consumption of frozen seafood, eggs, tomatoes, meat and prepared food in such countries as Sweden, Iceland and Finland.

The outbreaks were twice reported in Denmark and France. At least 134 humans were affected [21].

In 2012, five salmonellosis outbreaks involving 63 diseased humans were reported. One of the five cases was caused by *S. Oranienburg* from dry milk produced in Belgium from raw milk originating from South Korea. This dry milk was used in infant formula, sixteen Belgians were diseased. In Italy, salmonellosis incidence was reported following consumption of meat products from Romania, and in Austria – due to egg products from France. From June 14 to September 21, 2012, forty-one cases of *S. Bredeney* infection were reported in humans in 20 US states. Investigation results demonstrated that this serotype was present in peanut butter and peanut-based products marketed in France, Italy, Norway and United Kingdom [22].

In 2013, four salmonellosis outbreaks were reported in Sweden, France, UK and Finland, where 100 humans were affected, who consumed Chlorella from China, eggs from Spain, cooked ham from United Kingdom and salted chicken fillet from Thailand [23].

In 2014, the majority of notifications of *Salmonella* detection in milk products, eggs and egg products, dietetic foods, food supplements and feed were associated with products originated from France and Germany. Just in one year, eleven salmonellosis outbreaks were reported in the European countries: two outbreaks in Germany and Austria, three outbreaks in France, Italy, United Kingdom and Luxembourg. As a result, 238 humans were affected. The outbreaks were caused by the consumption of meat and dairy products, eggs and tiger shrimps. *S. enteritidis* was, inter alia, isolated from diseased humans following consumption of raw egg-containing ice-cream manufactured in Germany. A week later France notified of the second *Salmonella* outbreak; the disease was associated with the consumption of home-made chocolate cream prepared with raw eggs imported from Germany. Analysis of the remaining eggs revealed presence of *Salmonella*. The eggs from the German producer were recalled [24].

In early 2015, there were two notifications by France relating to outbreaks with *S. enteritidis*; 71 humans were diseased. In both cases, the cause of the disease was consumption of minced meat manufactured in Poland. Hereafter, two more notifications were made. Total of nine salmonellosis outbreaks were reported in France, Sweden, Austria, the Netherlands and Hungary; four out of these outbreaks were caused by *S. enteritidis* detected in meat products, dry vegetables and milk products. Poultry meat and caraway seed powder were also of poor quality. Two salmonellosis outbreaks were reported in the Netherlands and they were caused by the consumption of beef originated from Lithuania and Poland. At least 388 humans were diseased in 2015 [25].

According to the annual epidemiological reports by the European Centre for Disease Prevention and Control salmonellosis is the second most often reported gastrointestinal infection and cause of the food-borne disease outbreaks in the EU countries.

In 2011, 96,883 cases of *Salmonella* infection were reported in 29 EU countries; the confirmed disease incidence amounted to 20.4 cases per 100,000 population. The confirmed cases were mostly reported in Czech Republic (80.69 cases per 100,000 population), Slovakia (71.70) and Lithuania (70.70). Greece, Ireland, Italy, Portugal and Romania reported of at least 10 cases per 100,000 population. In 2011, *S. enteritidis*, *S. typhimurium*, monophase *S. typhimurium*, *S. infantis* and *S. Newport* prevailed. As compared to 2010, the number of *S. enteritidis* cases decreased by 6%, *S. Typhimurium* – by 9%. Notable increase of monophase *S. typhimurium* (157%) cases was due to two large-scale food-borne disease outbreaks in France (682 and 337 cases). In 2011, the list of the most widespread serovars included *S. Poona* being the cause of 548 cases of salmonellosis, the majority of which were reported in infants in Spain due to consumption of contaminated infant formula [15].

In 2012, twenty-nine EU/EEA countries notified of 92,438 confirmed cases of *Salmonella* infection; the disease incidence amounted to 21.9 cases per 100,000 population. The highest level of the confirmed cases was reported in Czech Republic (97.5 cases per 100,000 population) and Slovakia (85.6). Four countries notified of the level below 10 cases per 100,000 population: Greece, Ireland, Portugal and Romania. Notable increasing tendency was reported in France and the Netherlands. In 2012, four outbreaks of salmonellosis were reported in the EU/EEA countries. During a very large-scale outbreak in the Netherlands 866 cases were confirmed that were associated with the consumption of smoked salmon contaminated with *S. Thompson*. In January 2012, Germany notified of salmonellosis outbreak caused by the consumption of watermelons originated from Brazil and processed in the United Kingdom. The relatedness of the German *S. Newport* isolates and the Brazilian ones isolated in the United Kingdom and accessed to RASFF in 2011 was established. Mainly in December 2011, the isolate was also detected in the United Kingdom (32 cases in England and Wales, and 4 cases both in Scotland and Ireland) [15].

From August 2011 to December 2012, 688 *S. Stanley* infection cases were reported that were associated with the consumption of turkey meat in 10 EU countries: Hungary, Austria, Germany, Belgium, United Kingdom, Sweden, Italy, Greece, Czech and Slovak Republics. In 2012, the most widespread *Salmonella* serotypes included *S. enteritidis*, *S. typhimurium*, monophase *S. typhimurium*, *S. infantis* and *S. Stanley*. Late in August 2012, the Netherlands notified of the detection of 34 *Salmonella* infection cases caused by *Salmonella Thompson*. After the outbreak had already been notified, total of 1149 disease cases were reported and confirmed including four lethal cases in elderly patients [15, 16, 19].

In 2014, thirty EU/EEA countries notified of 91,408 salmonellosis cases including 89,883 laboratory confirmed cases (25.4 cases per 100,000 population). The decrease of salmonellosis cases is thought to be connected with the implementation of *Salmonella* control programmes in the poultry industry, particularly in laying hens and broilers. Nevertheless, salmonellosis remains the second most prevalent zoonosis in humans in the EU [19].

There is a clear seasonal variation in the number of reported salmonellosis cases with case numbers increasing over the summer months, peaking in August and September, and then decreasing. In 2014, the summer peak was slightly less pronounced than in the previous four years [19].

The highest notification rates in 2014 were reported by the Czech Republic (126.1 cases per 100,000 population) and Slovakia (75.3), followed by Hungary (53.1) and Spain (47.5); the lowest rates were reported by Portugal and Greece (≤4.0). *Salmonella* accounted for 1,048 foodborne

outbreaks in 2014, corresponding to 20% of all reported foodborne outbreaks, and eggs and egg products continued to be the most commonly identified vehicle in these outbreaks [19].

97,114 salmonellosis cases were reported by 30 EU/EEA countries in 2015, with 95,595 laboratory confirmed cases (22.9 cases per 100,000 population). Compared with 2014 (21.7 cases per 100,000), this represented a 6% increase in the EU/EEA notification rate. The highest notification rates in 2015 were reported by the Czech Republic (117.7 cases per 100,000 population) and Slovakia (89.3), which both have active surveillance of salmonellosis, followed by Hungary (49.7) and Spain (43.3); the lowest rates were reported by Portugal and Greece (≤5.0 per 100,000). The large increase in notification rates in Bulgaria (48%) and France (15%) was in line with an increase in the number of *Salmonella* outbreaks in these countries [18].

Regulation (EU) No. 1003/2005 on *Salmonella* detection and control prescribes mandatory testing of all parent breeding poultry flocks. Regulation (EU) No. 646/2007 was targeted at the reduction of *S. enteritidis* and *S. typhimurium* prevalence in broiler population, and Regulation (EU) No. 584/2008 was aimed at the reduction by December 31, 2012 of the serotypes' prevalence in turkeys to the level not exceeding 1% in parent flock and during feeding. These measures altogether resulted in the reduction of human cases of infection with these serotypes. However, there was no reduction of other *Salmonella* serotypes prevalent in poultry. Multidrug-resistant and/or high ciprofloxacin resistant clones of e.g. *S. Kentucky*, *S. Stanley* and *S. infantis* are also spreading in the animal and human population in the EU [19].

CONCLUSION

There are no legally prescribed microbiological criteria for *Salmonella* spp. in raw materials; RASFF notifications are based on national criteria or case-by-case risk assessments. For processed animal products, a criterion is set in Regulation (EU) No. 142/2011 of absence of *Salmonella* in 25 grams of the product.

From 2010 to 2015, there were 2,651 RASFF notifications on *Salmonella* spp. detection in food and feed, mostly in poultry meat, feed, fruits and vegetables, meat and meat products, herbs, spices and nuts. Over the above mentioned period, annual increase of *Salmonella* spp. notifications was reported for food (from 346 notifications in 2010 up to 522 2015).

Feed was the most often reported group as for *Salmonella* spp. detection from 2010 to 2013. The situation changed in 2013–2015 when poultry meat and poultry products took the first position and feed materials the second one.

In 2010–2015, total of 154 *Salmonella* serovars were detected in food and feed. The serotype diversity changes annually and generally demonstrates the increasing tendency. According to RASFF data the prevailing serotypes included: *S. enterica* – 32.4%; *Salmonella* spp. – 18.8%; *S. enteritidis* – 6.3%; *S. typhimurium* – 4.6%; *S. Agona* – 2.6%; *S. Lexingtone* – 1.4%. There were 99 serovariants detected just in feed, the majority of which, including *S. enterica*, *S. enteritidis*, *S. typhimurium*, *S. infantis*, *S. Kentucky*, *S. Give*, were also detected in poultry meat. Such serotypes as *S. Agona*, *S. Mbandaka* and *S. Livingstonewere* detected in feed as well, but they were scarcely detected in poultry meat.

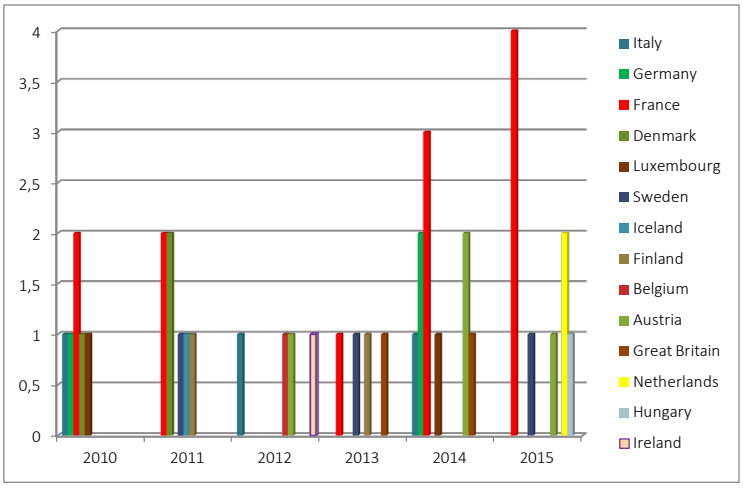


Fig. 4. Number of salmonellosis outbreaks in humans in the European Union, 2010–2015 According to RASFF data

Among the countries – manufacturers of the products non-compliant with these microbiological criteria – were Brazil, Germany, India, Mauritania, Morocco, Chili and USA.

Salmonella spp. were detected in poultry meat (19.5%), pet food (5.6%), pork (3.7%) and fishmeal (5.1%).

From 2010 to 2014, the number of notifications of *Salmonella* spp. detections in plant feed, mostly in soy and soy flour (6.8%), rape and rape flour (4.4%) from Brazil, Argentina, Germany, Netherlands and Italy.

Over 2010–2015, RASFF reported of 42 salmonellosis outbreaks that resulted to 1,586 humans to be diseased. *Salmonella* sources included not only egg, meat and dairy products but also watermelon, tomatoes, caraway seeds, seafood, Chlorella, peanut butter and peanut-based products.

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