

Carcinogenic food contaminants in European countries

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Contamination of food is inevitable in the production process from manufacturing to preparation for consumption. Some of the contaminants in food are serious health hazards and may increase the risk of cancer. Carcinogenic food contaminants include mycotoxins, dioxins, benzopyrene, acrylamide, cadmium and arsenic. European Union countries are required to meet standards for individual contaminants that may be present in food and to monitor these contaminants in products on the market. However, based on the European warning system for carcinogenic contaminants, it can be seen that they are still present in various countries of the EU. In view of the increasing number of cancer cases and the overall burden of non-communicable diseases on society, it is recommended to consider not only the nutritional value of food, but also the contamination of food with carcinogenic substances.

Key words: food contamination, risk assessment, human exposure, cancer risk, cancer prevention

Introduction

Cancer is a chronic disease characterized by specific risk factors, disease progression, and symptoms. It is the leading cause of death in Europe and has become one of the most urgent public health issues [1, 2]. The increasing number of cancer cases may be due to both individual and environmental factors, many of which are preventable. It is estimated that 30–50% of cancer cases are preventable [3]. In particular, lifestyle, including diet, is responsible for more than half of cancer cases in Europe [4, 5]. Food can promote carcinogenesis through naturally occurring substances, contaminants, or additives. The intake of carcinogenic food contaminants cannot be fully controlled by individuals, so making regulation and monitoring of its' levels is an important task for policymakers. Carcinogenic food contaminants can be of plant, fungal, and anthropogenic origin and can be present in the product both before and after processing. They also arise from contact with food packaging [6]. As far as diet and dietary habits have

a significant impact on individual cancer risk, carcinogenic food contaminants should also be considered. Food contaminants can be a risk factor for many cancers, so irresponsible behavior by manufacturers and consumers can lead to increased cancer incidence. In addition, the lack of appropriate regulations on testing, monitoring, and standards may pose an additional cancer risk to consumers. The effects of ingesting food contaminants can be observed immediately or over time. Some compounds may even be recovered in other generations [7]. Therefore, some food contaminants appear to contribute to the cancer burden due to chronic exposure in Europe in addition to other external risk factors. Noteworthy, food contaminants originate from the environment (water, soil, air), residues from agricultural activities, breeding activities, residues from technological processes, or packaging. In addition, carcinogenic compounds can occur during transportation, storage, and preparation for consumption. Since many of these processes where contamination can occur

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are beyond the control of the individual, the importance of monitoring contamination levels is repeatedly emphasized.

The objective of this review is to identify and characterize the contaminants in foods classified as carcinogenic in European countries that may pose a risk to humans and to present recommended methods for reducing exposure.

Food contamination monitoring in Europe

According to the International Agency for Research on Cancer of the World Health Organization (IARC) definition, a carcinogen is a compound or mixture of chemical compounds that induce the formation of a malignant tumor or increase the incidence of its recurrence [8]. The primary food ingredients, as well as chemical compounds added to foods (e.g., preservatives) or accidental food contamination, may be responsible for the carcinogenic effects of some foodstuffs.

The legal basis for regulating food contamination in Europe is Council Regulation 315/93/EEC [9]. This document sets maximum levels for certain contaminants to protect public health. The regulation states that contamination levels must be kept as low as reasonably achievable while following recommended good working practices. It also states that food contaminated to an extent unacceptable to public health, particularly in toxicological terms, shall not be placed on the market. The maximum levels for certain food contaminants are set in Commission Regulation (EC) No. 1881/2006 [10]. The maximum levels set in the documents are reviewed and modified as new scientific evidence becomes available. However, compliance with the European recommendations must be verified by the competent control bodies.

To provide appropriate verification procedures, the EU has established the Rapid Alert System for Food and Feed (RASFF), which serves to exchange information between official control authorities in Europe. Information on food, feed and food contact materials that are potentially hazardous to human, animal or environmental health is entered into the system when such products are identified. When a risk related to food, feed or food contact materials is identified, the national contact point of a given member of the network must send a notification to the iRASFF electronic system. In accordance with Art. 52 sec. 1 of Regulation 178/2002 and Art. 24 sec. 3, the European Commission makes information on alert, information and border rejection notifications publicly available through the RASFF [11].

Of the numerous contaminants that have been identified in food in the European Union, some have proven carcinogenic or potentially carcinogenic properties; some of them are described in this overview.

Food contaminants which pose a carcinogenic threat to humans

Mycotoxins

Mycotoxins are secondary metabolites of molds such as *Aspergillus*, *Fusarium* and *Penicillium* that are toxic and carcinogenic

to humans. These fungi are widely distributed on agricultural crops and contaminate subsequently produced food and feed. The most common mycotoxins are aflatoxin, ochratoxin A, patulin, fumonisins, deoxynivalenol, and zearalenone. In addition, molds are capable of producing more than one toxin under certain climatic conditions. This results in co-exposure to many mycotoxins from one product and the risk of associated adverse effects, including carcinogenicity [12]. Mycotoxins have been shown to have mutagenic, teratogenic, carcinogenic, and estrogenic properties. They are usually produced by improper food storage, and the most commonly contaminated products include corn and peanuts. They are also found in many other agricultural foods, such as cereals and cereal derivatives, spices, coffee, cocoa, tea, dried fruit, beer, wine, and powdered milk [13]. Mycotoxins can cause acute poisoning with damage to internal organs (liver, kidneys), however cases of acute poisoning are not so frequent [14]. On the other hand, chronic exposure may affect these organs and increase the risk of developing kidney or liver cancer, which will manifest as a long-term complication of exposure.

Aflatoxin is classified as carcinogenic to humans, and ochratoxin A is defined as possibly carcinogenic to humans according to the IARC classification and it primarily causes an increased risk of liver cancer [13]. Maximum allowable levels for aflatoxin b1 range from 0.1 µg/kg for wheat infant products to 8 µg/kg for peanuts. For ochratoxin, the permitted levels range from 0.5 µg/kg in infant products to 10 µg/kg for coffee or dried fruit. Between 2021 and 2022, the RASFF system issued 467 notifications of aflatoxin contamination on EU territory, of which 62 concerned aflatoxin B1 (tab. I). For example, one notification requested a rejection at the border due to aflatoxin in nutmegs on Danish territory. Notifications of aflatoxin also involved date syrup made with organic dates in Belgium, and nootmuskaat and basmati rice in the Netherlands. Ochratoxin A appeared 62 times in the RASFF system and was detected in organic whole rye pasta from Poland, among other products.

The recommended methods to reduce exposure to mycotoxins in daily life are to buy food as fresh as possible and consume it immediately. In addition, consumers should avoid hoarding purchases. It is recommended to store foodstuffs under proper conditions and in a cool place. Bread boxes and similar items should be cleaned once a week and rinsed with vinegar and water to prevent mold growth. It is also recommended to remove bread crumbs from bread boxes as they promote mold growth. Food that is already moldy should be removed immediately. Cereals and flour should be stored in a cool, dry place and shaken occasionally. Moldy jams and jellies should always be discarded, and those with lower sugar content should also be stored in the refrigerator [15].

Dioxins

The term "dioxin" generally refers to a group of structurally and chemically related aromatic hydrocarbons, including

Table I. Some of the RASFF notifications for aflatoxin in foodstuffs between 2021–2022

Category	Type	Subject	Date	Notifying country	Classification	Risk decision
nuts, nut products and seeds	food	aflatoxins in pistachios kernels from the United States	04.10.2022 14:13:32	Italy	border rejection notification	serious
nuts, nut products and seeds	food	aflatoxins in groundnut kernels from the United States	03.10.2022 11:18:23	Netherlands	border rejection notification	serious
fruits and vegetables	food	exceeding the MRL for aflatoxin and the sum of aflatoxins in dried figs from Turkey	30.09.2022 16:00:28	Poland	information notification for attention	serious
nuts, nut products and seeds	food	aflatoxin in Argentine groundnuts	30.09.2022 08:10:33	Netherlands	border rejection notification	serious
fruits and vegetables	food	aflatoxins B1 in organic dried figs from Turkey	29.09.2022 15:05:59	Germany	border rejection notification	serious
nuts, nut products and seeds	food	aflatoxins in pistachios	18.09.2022 14:46:08	Bulgaria	border rejection notification	serious
nuts, nut products and seeds	food	almonds from US with aflatoxins level higher than allowed levels	16.09.2022 13:28:59	Spain	border rejection notification	serious
herbs and spices	food	aflatoxin in Pakistan Chapli Kabab	14.09.2022 14:39:17	Netherlands	border rejection notification	serious
nuts, nut products and seeds	food	aflatoxin in USA groundnuts	13.09.2022 16:09:23	Netherlands	border rejection notification	serious
nuts, nut products and seeds	food	aflatoxin in Argentine groundnuts	13.09.2022 16:07:41	Netherlands	border rejection notification	serious
nuts, nut products and seeds	food	aflatoxins in groundnuts from Nigeria	13.09.2022 16:00:27	Belgium	border rejection notification	serious

75 polychlorinated hydrocarbons, dibenzo-p-dioxins (PCDDs) – chlorinated dibenzo-1,4-dioxin derivatives, and 135 polychlorinated dibenzofurans (PCDFs). Sometimes the term “dioxins” refers generally to the group of halogen derivatives of aromatic hydrocarbons that have a similar structure and similar properties, or it is used to refer to the most biologically active member of this group of contaminants, i.e., 2,3,7,8-tetrachlorodibenzo-p-dioxins [16]. Dioxins are formed as by-products of various uncontrolled combustion processes, as well as in industrial processes (in ferrous and nonferrous metal smelters, cement plants), and also in fires and volcanic eruptions. These substances are persistent in all elements of the environment (the half-life in humans is 7–8 years on average). Dioxins are subject to bioaccumulation and are transported for long distances through air, water, and migratory species. As a result, they are deposited far from the sites of their emission, where they then accumulate in terrestrial and aquatic ecosystems and pose a threat to the environment and human health [17–19].

Accumulation of dioxins in the food chain is particularly hazardous and should be of interest to public health professionals. Food is responsible for the majority of dioxin intake in humans, and the most common dietary sources of dioxins are:

- meat and meat products – 27.5%,
- fish and fish products – 27.0%,
- milk and canned foods – 26.9%,
- oils – 3.8% [20].

Dioxins are fat-soluble compounds, therefore dietary fat increases their absorption. In addition, dioxins can accumulate in the body, which increases the health burden of dioxins with age [21]. The carcinogenicity of dioxins has been investigated in several epidemiological studies, which found an increased risk of cancer, but no cancer type was the main focus. Therefore, in the case of dioxins, an overall increase in cancer risk was found rather than an increase in the likelihood of developing cancer at a specific site [22].

Dioxins, particularly 2,3,7,8-tetrachlorodibenzo-para-dioxin, are classified as carcinogenic to humans according to the IARC classification. Maximum allowable levels for dioxins in food range from 0.3 pg/g fat in vegetable oils to 12 pg/g fat in animal meat. The RASFF notification for dioxins in the EU territory between 2021 and 2022 concerned, for example, dioxins and dioxin-like PCBs in goose breast fillets and legs from Hungary or fish oil from China in the territory of the Netherlands (tab. II).

Suggested methods to limit dioxin exposure include, for example, restricting the consumption of animal fats, since dioxins are compounds that are fat-soluble. In addition, it is recommended to choose products with a lower fat content, for e.g. as low fat dairy products. It is also recommended to remove the skin from meat products. Additionally washing of vegetables and fruits before consumption may also have a positive impact on the potential risk of dioxin contamination from other sources [23].

Table II. The RASFF notifications for dioxins in foodstuffs between 2021–2022

Category	Type	Subject	Date	Notifying country	Classification	Risk decision
feed materials	feed	dioxins (sum of dioxins and furans: 0.75 ng/kg) in copper sulphate pentahydrate from Thailand	02.08.2022 17:31:15	Netherlands	information notification for attention	not serious
feed materials	feed	dioxins in refined fish oil from China	14.06.2022 15:02:42	Netherlands	information notification for attention	serious
fats and oils	feed	exceedance of the action threshold for dioxin in palm fatty acids (animal feed) from Germany	03.05.2022 17:55:33	Germany	information notification for follow-up	undecided
fats and oils	food	dioxins and dioxin-like PCBs in goose breast fillets and thighs from Hungary	21.12.2021 17:00:17	Hungary	alert notification	serious

Benzopyrene

Benzopyrene is one of the PAHs (polycyclic aromatic hydrocarbons), a group of chemical compounds formed naturally or by humans during pyrolysis or incomplete combustion of organic materials, including wood, coal, petroleum and its products, as well as petrochemical processes, food processing, smoking, etc. These compounds are widely distributed in the environment and can be found in the air, soil or water. Depending on the conditions, they can be absorbed through the respiratory tract as solid aerosols, through the skin, or through the gastrointestinal tract after ingestion with drinking water, food, soil (especially in children), and breast milk [24–26]. PAHs are a ubiquitous and highly diverse group of contaminants found in both the natural environment and in food. The extent of contamination with PAH compounds from natural sources is low. The main source of contamination is industrial processes resulting from human activities.

The group of PAHs includes several compounds with a complex structure that may contain two to several dozen interconnected benzene rings, indicating different physicochemical and toxic properties. PAHs are mainly formed during pyrolysis, especially during incomplete combustion of organic raw materials, and thus also during smoking (smoked foods). They are usually formed during the combustion process, which takes place at temperatures between 500°C and 1000°C or higher. Most PAHs are formed during combustion at a temperature of 500°C to 700°C with limited air access to the combustion zone, e.g. during wood combustion. Up to 10,000 chemical compounds with the structure of polycyclic aromatic hydrocarbons and their derivatives can be formed during combustion processes. Therefore, PAHs in food are mainly caused by environmental pollution and some technological food preservation processes, such as smoking, frying, or grilling [27].

Benzopyrene is considered one of the most convincing carcinogens because of its structure that allows easy alkylation of DNA. Damage to DNA structure combined with increased production of reactive oxygen species (ROS) makes benzopyrene a potent carcinogen, and these mechanisms are well

described in the literature [28, 29]. Despite the lack of epidemiological studies, benzopyrene has been classified as a human carcinogen based on sufficient number of mechanistic evidence and animal model studies [30].

The major sources of benzopyrene in foods are fried, grilled, and smoked meats as well as fried, baked, and deep-fried products [high-temperature processing]. Benzopyrene can be also found in cereals and other grains or vegetables grown on contaminated soils. The maximum allowable level of benzopyrene in food ranges from 1 µg/kg in infant formula products to 10 µg/kg for clams. From 2021 to 2022, there were 13 notifications in the RASFF system of benzopyrene, for example in sunflower oil from Ukraine on the territory of Lithuania or in kabanos sausage in Slovakia (tab. III).

To reduce exposure to benzo[a]pyrene, it is recommended to reduce the consumption of smoked and fried foods or highly processed food [31].

Acrylamide

Acrylamide is an organic chemical compound of the amide group that does not occur naturally in the environment. Acrylamide is obtained by hydrolysis of acrylonitrile and is an odorless, crystalline substance. The main use of acrylamide is in the manufacture and synthesis of polyacrylamides, which are used in the production of plastics, paints, adhesives, varnishes and mortars. Acrylamide is found in many foods such as bread, French fries, cakes, and fried meats. Acrylamide is a chemical compound usually formed in starchy products by frying or baking at high temperatures (120–150°C). The main chemical reaction is the so-called Millard reaction, in which naturally occurring sugars and amino acids in starch products combine to form substances that yield new flavors and aromas. It also leads to a brown coloration of the skin of heated foods and the formation of acrylamide.

According to the EFSA opinion, epidemiological studies available to date have shown that acrylamide intake was not associated with an increased risk of most common cancers, including gastrointestinal or respiratory tract cancers, breast, prostate and bladder cancers. Several studies suggest an in-

Table III. The RASFF notifications for benzopyren in foodstuffs between 2021–2022

Category	Type	Subject	Date	Notifying country	Classification	Risk decision
herbs and spices	food	benzopyrene and polycyclic aromatic hydrocarbons (PAHs) in dried bay leaves from Bangladesh, via Spain	19.09.2022 15:31:34	Germany	alert notification	serious
cocoa and cocoa preparations, coffee and tea	food	benzopyrene and polycyclic aromatic hydrocarbons (PAHs) in matcha tea powder from China, via the Netherlands	05.08.2022 10:59:23	Germany	information notification for follow-up	not serious
fats and oils	food	exceeding the MRL for benzopyrene in sunflower oil from Ukraine	29.06.2022 17:25:29	Lithuania	information notification for attention	serious
herbs and spices	food	benzopyrene and polycyclic aromatic hydrocarbons (PAH) organic paprika powder from Spain	04.05.2022 14:18:25	Germany	alert notification	serious
herbs and spices	food	benzopyrene and polycyclic aromatic hydrocarbons in organic paprika powder from Spain	21.12.2021 17:41:06	Germany	alert notification	serious
fish and products thereof	food	benzopyrene e PAH4 in smoked <i>sardinella aurita</i>	19.10.2021 12:49:04	Italy	information notification for attention	serious

Table IV. The RASFF notifications for acrylamide in foodstuffs between 2021–2022

Category	Type	Subject	Date	Notifying country	Classification	Risk decision
cereals and bakery products	food	acrylamide content	04.10.2022 14:37:54	Slovenia	border rejection notification	no risk
cereals and bakery products	food	acrylamide in crunchy haverkoek	05.07.2022 16:57:40	Netherlands	information notification for attention	undecided
cereals and bakery products	food	content of acrylamide above the achieving level in crackers	29.06.2022 11:18:18	Slovenia	border rejection notification	not serious
cereals and bakery products	food	high content of acrylamide in biscuits from Bosnia and Herzegovina	02.05.2022 08:35:40	Croatia	border rejection notification	serious
cereals and bakery products	food	acrylamide in organic spelt biscuits	29.12.2021 15:59:02	Netherlands	information notification for follow-up	not serious

creased risk of renal, endometrial [especially in nonsmoking women], and ovarian cancers, but the evidence is insufficient [32]. From the IARC monograph, it can be concluded that acrylamide and its metabolite glycidamide form covalent adducts with DNA in mice and rats. In addition, acrylamide causes genetic mutations and chromosomal aberrations in rodent somatic cells *in vivo*, cultured cells *in vitro*, and mouse germ cells. The final assessment states that acrylamide is possibly carcinogenic to humans (Group 2A) [13].

The European Commission's maximum limits for acrylamide in food range from 50 µg/kg or wheat-based bread to 850 µg/kg for instant coffee. Acrylamide was reported in the RASFF system five times between 2021 and 2022, and all notifications involved cereals and bakery products on the territory of Slovenia, the Netherlands, and Croatia (tab. IV).

To reduce exposure to acrylamide, it is recommended to reduce cooking time to avoid severe crispiness or browning, blanch potatoes before frying, and avoid storing potatoes in the refrigerator. In addition, post-drying (drying in a hot air oven after frying) has been shown to reduce acrylamide levels in some foods [33].

Cadmium

Cadmium is one of the heavy metals present in the environment through both natural occurrence and industrial and agricultural sources. Exposure to cadmium in the nonsmoking population occurs primarily through food. The accumulation of dangerously high concentrations of cadmium in the environment is mainly due to anthropogenic activities such as phosphate fertilizers, sewage, sewage sludge, and manure [34].

Due to various factors, cadmium enters water and soil, from where it is absorbed into plants. Thus, cadmium enters the food chain and poses a risk to human health [35] osteoporosis, diabetes, cardiovascular disease and cancer. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) cadmium is usually found in vegetables [leafy greens, potatoes], cereals, or kidneys and livers of animals.

Symptoms such as stomach irritation, abdominal cramps, nausea, vomiting, and diarrhea may be observed in acute cadmium poisoning, but usually only small amounts of this element are absorbed from food. Nevertheless, small doses of dietary cadmium can accumulate in the body and cause long-term side effects such as cancer. Chronic cadmium exposure has also been associated with chronic kidney disease, diabetes, and osteoporosis [36–38]. Cadmium has been found to disrupt hormone balance, interact with antioxidant enzymes, deregulate cell proliferation, or inhibit cell apoptosis, which likely accounts for its pro-carcinogenic properties [39]. Scientific evidence has confirmed the association between cadmium and increased risk of lung cancer, but it has also been found to be associated with breast, kidney, and prostate cancer [40].

According to Commission Regulation (EU) 2021/1323 of August 10, 2021, amending Regulation (EC) No. 1881/2006 as regards the maximum levels of cadmium in certain foodstuffs, the cadmium content limits were reduced, for example, to 1.20 mg/kg wet weight in poppy seeds or to 0.02 mg/kg wet weight for fruits. Between 2021 and 2022, information on excessive cadmium levels in foods was identified 58 times in the RASFF system (tab. V). The high cadmium content was detected in flaxseed, seafood, and avocado, among others. In addition, some of the notifications were related to warnings about high migration of cadmium from glass.

To reduce cadmium exposure, it is recommended to avoid smoking and second-hand smoke. Washing fruits and vegetables as well as peeling roots and tubers can also reduce cadmium contamination to some extent [41].

Arsenic

Arsenic is counted among the semimetals because of its specific properties. It is a highly toxic element widely distributed in nature, which is absorbed into the body through the digestive and respiratory tract. Under certain conditions, arsenic found in soils and minerals can be released into water.

Table V. Some of the RASFF notifications for cadmium in foodstuffs between 2021–2022

Category	Type	Subject	Date	Notifying country	Classification	Risk decision
fish and products thereof	food	cadmium in giant squid arms from Lithuania	26.09.2022 16:14:29	Germany	alert notification	serious
meat and meat products (other than poultry)	food	cadmium in horse meat from Romania	20.09.2022 12:39:56	Belgium	alert notification	serious
fruits and vegetables	food	cadmium in spinach	19.09.2022 12:12:54	Belgium	alert notification	serious
bivalve molluscs and products thereof	food	cadmium in cooked mussel meat from Chile	14.09.2022 17:24:43	Netherlands	alert notification	serious
fruits and vegetables	food	cadmium in green asparagus from Peru	12.09.2022 16:26:03	Netherlands	information notification for attention	serious
fruits and vegetables	food	frozen carrot finding that the MRL for cadmium has been exceeded	06.09.2022 15:55:15	Poland	information notification for follow-up	not serious
fruits and vegetables	food	cadmium in spinach from Poland, raw material from Germany	02.09.2022 15:24:53	Poland	information notification for attention	serious
food contact materials	food contact material	migration of cadmium and lead from glasses	22.08.2022 15:27:34	Poland	alert notification	serious
cephalopods and products thereof	food	Patagonias squid, presence of cadmium higher than the legal limits in calamar Patagonico – Patagonias squid	22.08.2022 12:24:51	Italy	alert notification	serious
fruits and vegetables	food	cadmium in carambola	05.08.2022 15:27:00	Netherlands	information notification for attention	serious
fruits and vegetables	food	cadmium in organic avocado from Peru	02.08.2022 17:27:24	Netherlands	information notification for attention	serious

Table VI. The RASFF notifications for arsenic in foodstuffs between 2021–2022

Category	Type	Subject	Date	Notifying country	Classification	Risk decision
feed materials	feed	arsenic in monocalciumphosphate for feed from Turkey	20.04.2022 17:19:41	Denmark	information notification for follow-up	undecided
feed materials	feed	increased arsenic content in the supplementary feed for horses from Germany	29.03.2022 17:16:10	Germany	information notification for follow-up	undecided
fish and products thereof	food	arsenic (11.2 mg/kg – ppm in frozen cod [<i>Gadus Morhua</i>]) from Russia	08.11.2021 11:35:35	Poland	information notification for attention	undecided

The largest amounts of arsenic enter the environment through anthropogenic activities such as smelting, mining, and pesticide use. In many countries [e.g., India, Vietnam, or Taiwan], arsenic levels in groundwater are alarmingly high. In Europe, the most severe water contamination by arsenic was found in Hungary, Serbia, and Romania, where 600,000 people were at risk of drinking water that may have had elevated arsenic levels [42, 43].

Drinking water is the most common route of arsenic exposure in humans. Food studies have shown that arsenic is also present in foods, with arsenic levels depending on the type of food. Although the studies conducted to date have not detected significant levels in foods, it is important to monitor its levels because of the highly toxic properties of arsenic [44]. Inorganic arsenic compounds are known to cause lung, urinary bladder, and skin cancer. In addition, a positive association has been also found for arsenic exposure and kidney, liver and prostate cancer [45].

The maximum levels for inorganic arsenic in food are 0.1 µg/kg in rice intended for the manufacture of food for infants and young children and 0.3 µg/kg in rice cakes, rice wafers, rice crackers, and rice cakes. Three notifications of high levels of inorganic arsenic in food have appeared in the RASFF system, of which two warnings related to feed and one to food for human (tab. VI).

The recommended methods to reduce exposure to inorganic arsenic are polishing the grains, washing the paddy rice, boiling [in excess water], rinsing the rice grains (3 cycles), and then boiling in excess water. In addition, rice-based beverages should not be used in infants and children to protect sensitive populations [46].

Conclusions

Food can pose a carcinogenic threat to humans through the content of harmful substances naturally occurring in food, but also through carcinogenic pollutants. The food studies conducted so far have shown that the global problem of environmental pollution is also reflected in foods that may be contaminated with carcinogenic compounds. In the European Union, food contamination monitoring is carried out by dedicated food safety authorities, and exceedances of the recommended standards are recorded in the RASFF alert system.

Despite setting precise standards for carcinogenic food contaminants in the RASFF system, there are reports of harmful levels of some contaminants.

Carcinogenic food contaminants include, but are not limited to, mycotoxins, dioxins, benzopyrene, acrylamide, cadmium and arsenic. These substances are classified as carcinogenic to humans and for each of them it was confirmed that the acceptable level was exceeded at least several times in the last year. Due to the fact that food can be an important element influencing the individual and population cancer risk, not only the nutritional value of the diet should be considered but also the quality of products and the levels of contaminants present in them.

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