Chapter 8

Contaminants in Animal Products

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Additional information is available at the end of the chapter

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Abstract

Organic and conventional animal products may include residues of veterinary drugs and environmental contaminant. Food contaminants can cause consumer illness such as allergy, immunosuppression, cancer, teratogenicity, mutagenicity and genotoxicity. Therefore, their control is an important issue in terms of public health. In this article, information is given about contaminants such as bacterial, fungal, metal pesticides and veterinary drug that can be found in organic and conventional animal products. In addition, the effects of various cooking and freezing processes on contaminants in animal foods and their legal regulation have been mentioned.

Keywords: contaminant, animal, product, organic, conventional

1. Introduction

Chemical substances have been used excessively in order to increase the agricultural productivity since the 1940s. Applications initially led to an apparent increase in yield. However, in the later process, effectiveness of these substances decreased due to the development of resistance against chemicals, particularly used in combating agricultural pests, thus this situation resulted in either excessive use of them to obtain better response or development of new drugs with high expenses. Moreover, in this course, human, animal and environmental health problems are reached much more serious extent besides the economic losses [1]. This situation, particularly, in the developed countries has led people to consume more safe products. The current approach is more comprehensive, which ensure the dissemination of sustainable practices in every production area in order to leave a healthier world for future generations.

Organic farming, emerged in this context, is accepted as the farming not allowing the use of any of the substances/applications such as growth promoters, antibiotics, genetically modified organisms and irradiation, which are considered to be harmful to human health, and providing safer foods concerning nitrates, pesticides and harmful elements (heavy metals, particularly cadmium) and rich in phenolic compounds and vitamins [2, 3].

2. Contaminants in organic animal products

Organic farming refers to breeding systems that do not use chemical inputs in which the priority is given to animal welfare and quality of healthy products [4]. In organic livestock production system, vaccination is subjected to conditional permission [5]. Organic farming has increased intensely for the last 10 years in Europe. However, difficulties in the treatment of animal diseases due to failure in achieving the standards of organic farming has led to insufficient development of organic farming and to have a small share in the overall agriculture [4]. Although milk is the most commonly produced products among the organic animal products, its production amount is still considerably lower than that produced by the conventional method. The organic meat production has been recently introduced; therefore, it is difficult to find certified breeders [6]. According to 2001 data, concerning the organic animal breeding, Europe takes the first place with 57.9%, which is followed by the North (15.5%) and South America (13.9%). Organic animal product quality varies depending on various factors such as animal species and diet types. Although, concerning some parameters, organic animal products are superior to conventional animal products, generally, they are considered not to be superior to conventional ones in terms of quality [7]. Despite all this, the organic products are generally regarded as excellent products. For this reason, researches on the contamination in organic products, especially, organic animal products are limited [8]. However, unlike the conventional farming, lack of the use of protective products in organic products can lead to early deterioration of a product, to the risk for mold formation and to the emergence of harmful pathogens. On the other hand, despite all the strict rules of organic farming, inevitable factors such as atmospheric conditions, soil properties, climatic conditions, continuation of permanent pollutants for years may cause the residues in organic vegetables and cereals thus indirectly (with food intake) results in negative factors/residues in animal products [9].

2.1. Bacterial contaminants in organic animal products

In organic farming, various factors such as use of animal manure, the prohibition of the usage of certain food additives and antibacterials, keeping animals on pasture for longer duration, preferring slow-growing breeds and small slaughterhouses makes organic products vulnerable to bacterial contamination [2, 10, 11]. Studies on bacterial contamination of organically grown animals and animal products are very limited. In fact, concerning the risk of bacterial contamination among organic products, plant products have priority. In terms of organic animal products, poultry meat seems to be more risky. Salmonella and Campylobacter are the most important foodborne bacterial contaminants [10]. Salmonella can lead to disease in humans through consumption of contaminated beef, pork, poultry meat and eggs or vegetables contaminated with animal faces [12]. Differences are seen between the results obtained from the conventional and organic products in terms of contamination with bacteria. In a study, Salmonella was seen in none of the organic chicken farms (layers and broilers), whereas it is evident in approximately 10% of conventional farms, but Campylobacter was observed in all organic broiler farms [13]. Cui et al. [10] analyzed organic and conventional eggs collected from Maryland (USA) retail stores for Campylobacter and Salmonella, and detected Campylobacter in most of the organic (76%) and conventional (74%) chickens and Salmonella was seen in 61 and 44% of organic and conventional chicken, respectively. In the United Kingdom, Campylobacter was found in 80% of organically grown chicken. In a study conducted in Germany, it had been reported that organic chicken meat was contaminated with extended-spectrum beta-lactamase (ESBL) as much as conventional poultry meat [14, 15]. In organic or free-range hen breeding contamination of eggs with the faces and thus the risk of bacterial contamination of eggs is higher than the conventional cage breeding [16]. Antibiotic resistance of the bacteria isolated from organic and conventional chicken and also eggs derived from them differ. In a study, no difference was determined between organic and conventionally grown chickens regarding sensitivity of Campylobacter isolates to antibiotics [15]. In another study investigating antibiotic resistance against Gram-negative bacterial isolates, the resistance in isolates obtained from organically reared chicken is lower because of the limited use of antibiotics in organic farming [17]. Isolates obtained from Campylobacter and Salmonella positive organic chicken eggs were found sensitive to antimicrobial agents, whereas isolates derived from conventional chicken eggs were resistant to five or more antibacterial agents [10]. Similarly, in the Netherlands, antibiotic resistance was lower in microorganisms (except Campylobacter) isolated from faeces samples of organic broilers [13].

It was observed that Salmonella contamination status varies in organic fattening pig farms depending on the breeding experience of the farms [12].

Organically grown animals have a lower risk of bovine spongiform encephalopathy (BSE, mad cow disease) just because they are fed with organic feed [7]. In cattle breeding, there is no basis (evidence) associated with organic production systems in terms of *Escherichia coli* (0157: H7) epidemics. In fact, a meat product such as undercooked minced meat is considered as responsible for the outbreaks due to this microorganism [18]. In a study monitoring the tetracycline residues (tetA and tetB) and tetracycline resistant bacteria in organic meat and vegetable-based baby foods, tet genes have been found in all organic products, particularly higher tetA have been detected in those from poultry origin, which indicates that organic foods are not better than conventional ones [19].

The bacterial count in raw milk is considered as an indicator of hygienic management of the farm. According to the European Union (EU) Council Directive (EC 92/46/EEC) for the production of heat-treated drinking milk, plate count (30°C) for per ml of milk should be ≤100,000, somatic cell count-SSC for per ml of milk should be ≤400,000 in cows' milk and plate count (30°C) for per ml of milk should be ≤1,500,000 in goat's and sheep's milk [20]. In a comparative study, total mesophilic bacteria count-TMBC ($\times 10^3$ CFU/mL) and coliform bacteria count-CBC ($\times 10^1$ CFU/ml) content of organic milk samples (for mesophilic n = 218; for coliform n = 101) were higher than conventional milk (for mesophilic n = 1168; for coliform n = 473) [21]. In one of the two different studies conducted in USA, no difference was present between organic and conventional (sum of grazing and not grazing) milk regarding SSC [22], and in the other study, very little difference was determined in terms of SSC and standard plate count [23]. Although no difference was found between organic and conventional milk samples concerning the diversity of spore forming aerobic bacteria, bacteria isolated from milk obtained from conventional farms were found to be more resistant to heat, and *B. cereus* organisms were abundant in organic milk, whereas *Ureibacillus thermosphaericus* were abundant in conventional milk. It has been suggested that this situation may be related to dietary strategy in the farm [24], and restricted silage use in organic ruminant breeding may reduce the bacterial contamination (*Listeria monocytogenes, E. coli* O157s) [24, 25].

2.2. Fungal contaminants and mycotoxins in organic animal products

Mycotoxins are toxic molecules, which are synthesized by molds growing on plants. These highly toxic and heat-resistant toxins are transferred to animals with plants, and to humans with animal products through the food chain. Among the mycotoxins, particularly aflatoxin (AFL), ochratoxin (OTA), fumonisins, deoxynivalenol (DON), patulin and zearalenone are the most important mycotoxins for public health. Mycotoxin contamination in animal products is lower than in those from plant origin. Studies comparing the organic and conventional animal products concerning mycotoxin contamination is limited [25].

In Latvia, mold strains belonging to 15 genera were identified in the raw milk samples collected from organic farms between December 2011 and November 2012. Among these strains, the most common ones were *Absidia, Aspergillus, Apophysomyces, Mucor, Penicillium* and *Rhizopus* spp. [26]. In a study of Ghidini et al. [6], Aflatoxin M1 levels in organic (Mean 35 ng/L; Range <5–93 ng/L) was found to be higher than conventional (Mean 21 ng/L; Range <5–66 ng/L) milk samples. The Aflatoxin M1 levels in 49% of the organic and in 10% of conventional milk samples were higher than the legal limit of 50 ng/L, which was set by EU Regulation 466/2001. However, in general, the samples were accepted as safe. In a study analyzing the organic and conventional milk samples for mycotoxins, OTA was detected in 6 out of 40 (11–58 ng/L) conventional milk samples and 5 out of 47 (15–28 ng/L) organic milk samples. OTA was not found in any of 20 baby food. The levels found in milk were higher than 5 ng/kg/day, which is the value for tolerable daily intake-TDI. It has been reported that consumption of such milk would be harmful for children [27]. In Greece, aflatoxin M1 (AFM1) (range 5–10 ng/L) was detected by ELISA in 196 different types (conventional, organic and children's milk) of milk samples collected from the market between November 2009 and June 2010. However, the AFM1 level determined in only two of the samples were higher than the maximal limit set by EU [28]. In a study conducted in Italy, feed and serum of conventional and organic layers and broilers were analyzed, and ochratoxin A (OTA) was found in all of the feed samples (100%). But not above limits set by the EU. OTA rates were high especially in the sera of laying hens on both organic (73%) and conventional (52%) systems, but there was no statistical difference between the laying hens vs broiler group [29].

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An OTA contamination (mean 0.05 μg/kg) in organic pork (4/7) was determined by a study conducted in Denmark between 1993 and 1994 [30].

2.3. Metal residues in organic animal products

Although, mineral supplementation in organic animal husbandry is not a routine practice, mineral supplements can be applicable. The diet of the animals in organic farming must be 100% organic [31]. Since organic animals depend on the mineral content in the soil, unlike the expectation, mineral deficiencies can occur in animals. This condition usually results in lower essential elements levels in organic animal products compare to conventional animal products. A study conducted in Spain investigating the levels of essential elements such as Cobalt (Co), Chromium (Cr), Copper (Cu), Ferrous (Fe^{2+}), Iodine (I), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Selenium (Se) and Zinc (Zn) and toxic elements such as Arsenic (As), Cadmium (Cd), Mercury (Hg) and Lead (Pb) in organic and conventional milk samples has revealed that levels of essential elements in organic milk is lower than conventional milk and toxic element concentrations are lower in both without any significant difference [32]. The analysis of pork obtained from slaughterhouses (n: 20) has shown that As, Pb and Hg (excluding one sample, 0.008 mg/kg) are below the detection limit (0.1, 0.05 and 0.005 mg/kg, respectively). In the same samples, Cd levels were between 0.005 and 0.38 mg/kg (median: 0.11 mg/kg), which were lower than the limits set by the EU (1 mg/kg) [13].

Heavy metals are persistent pollutants like organic chlorine and polychlorinated biphenyl (PCB) pesticides. Since heavy metals still exist in production processes for different purposes, they can be found in high levels in various environmental samples especially in pastures close to industrial areas [6]. Heavy metals enter the body through inhalation of their dust, drinking of the contaminated water or ingestion of the products grown in the contaminated regions (food chain) [33].

Some researchers have shown that levels of harmful elements such as Pb, As, Cd and Ni in organic products are not lower than those found in conventional products [6, 34, 35]. In a study evaluating a total of 156 organic and conventional milk and meat products (78 samples in each group), the mean Pb levels were detected as 1.85 and 1.68 μg/L and the mean Cd levels were detected as 0.09 and 0.16 μg/L in organic and conventional milk samples, respectively. In meat samples, the means of 5.91 and 14.81 μg/L Pb and the means of 0.49 and 1.31 μg/L Cd were detected in organic and conventional samples, respectively. Pb levels in organic and conventional milk samples were not higher than the 20 μg/L, which was set by EU Regulation 466/2001. There is no maximum residue limit (MRL) value for Cd-concerning milk. In the case of meat samples, Pb and Cd levels were lower than 100 and 50 μg/kg, which were set by EU Regulation 466/2001, respectively [6].

In Poland, milk and hair samples obtained from Holstein cow on organic farms were analyzed for Aluminum (Al), As, Barium (Ba), Cd, Cr, Cu, Fe, Hg and Pb, and the mean values of these elements in milk samples were 63.64, 12.27, 26.36, 1.130, 15.76, 157.6, 785.7, 0.396 and 6.210 μg/kg, and the mean values in hairs were 14224, 34.82, 298.7, 2.700, 75.76, 2263, 15925, 82.78 and 32.67 μg/kg, respectively [36].

In Turkey, in a study conducted on milk and milk products offered to consumption between March 2010 and February 2011, samples of conventional and organic products were collected at three monthly intervals and analyzed by Graphite Furnace AAS for Al, As, Cd and phosphorus (P), and the levels of these elements were found lower than limit of detection-LOD values, which were 0.02, 0.001, 0.001 and 0.02 μg/L for Al, As, Cd and Pb, respectively. Mean Pb levels were found as 0.001 ppm in organic milk (n:3) while 0.008 ppm in organic cheeses (n:7). There is not a maximal limit set by Turkish authorities for organic products, therefore, when 0.02 ppm, which was set as maximal acceptable value for the milk according to Turkish Food Codex "Communiqué on Determination of Maximum Level of Certain Contaminants" (Communiqué No: 2002/63) in foodstuffs, was taken as the basis, the Pb levels determined in one organic cheese and in one organic butter were above the maximum acceptable level [37, 38].

In a study performed in Turkey (Aegean Region) for determining the mineral content of the organic and conventional chicken eggs, compare to conventional chicken eggs, P and Zn levels in the edible portion of organic chicken eggs were lower, whereas Mg was higher in shell, and there was no difference between organic and conventional eggs concerning calcium (Ca), Fe and Cu contents [39]. In Turkey, 0.020, 0.055 and 0.020 mg/L of Cd, Pb and Cu, respectively, were found below the LOD in all of the organically and conventionally produced flower honey and eggs by analysis, whereas Fe concentrations were found at higher levels in organic compared to conventional products [40].

In Greece, in a controlled study, Cu, Vanadium (V), Cr, Ni, As and Cd contents were determined in conventional, organic and free-range (in the courtyard) chicken eggs, and mean values for these elements were determined as 1357, 12.5, 66.2, 63.3, 13.9, 1.4 ng/g in conventional, as 1233, 13.2, 82.9, 58.4, 12.5, 1.6 ng/g in organic and as 1282, 12.6, 90.5, 59.2, 15.4 and 1.5 ng/g in free-range chicken eggs, respectively. The values were lower in white than those in brown eggs [41]. In Egypt, in the analysis of organic eggs for Cd, Pb and Al showed that Cd and Pb were present in 34 and 40% of the organic eggs, respectively. The Cd and Pb contents of the eggs were above the maximum permissible levels. It was emphasized that although, when calculated according to target hazard quotients (THQ) organic eggs appear to have a low health risk, they are not safer than conventional ones [42].

Analysis of Cd levels in liver, kidney and fecal samples as well as feed, soil and water samples collected from a pig farm in which organic (outdoor) and conventional (indoor) breeding systems implemented together showed that Cd levels in organically and conventionally produced feedstuffs were 39.9 and 51.8 μg/kg, respectively. Cadmium content in 38% of the feed given to conventionally reared animals was found to be associated with the Cd content of beet fibers, which was included in to diet at a rate of 5%. No difference was determined between liver samples collected from the animals on organic and conventional feeding systems concerning Cd levels (15.4 ± 3.0 μg/kg). Despite the low amount of Cd in feed, more Cd was found in kidney of pigs fed with organic feed. In addition, Cd levels were higher in the feces of organic pigs, which were attributed to environmental exposures such as soil [43].

2.4. Pesticide residues in organic animal products

Organic products contain more phytochemicals, which are protective against pests, therefore, use of pesticides is not required, thus the risk of pesticide residues in organic products is low

[34]. However, from time to time, pesticides such as DDT and its degradation products, DDE may be found in foods such as organic-grown grain, grain products (biscuits, bread, etc.), meat and dairy products. Despite the use of pesticides in organic farming is not allowed, the reason for the existence of these substances in organic farming is attributed to the ability of them to remain in environment for a long time without disintegration [44]. Pesticides can be encountered in most of the animal products (meat, milk and fish) depending on bioaccumulation. Dioxin and dioxin-like compounds (polychlorinated dibenzo-p-dioxins-PCDD, polychlorinated dibenzofurans-PCDF, and polychlorinated biphenyls-PCBs), which are a general problem of the places in where industrialization is intense or intensely populated create similar problems for organic or conventional farming [45]. It has been stated that 4% of dioxin received by people per day comes from the eggs [46]. It has also been claimed that more dioxin was determined in eggs obtained from free-range hens compared to those obtained from hens grown indoors [45]. In a study conducted on honey for the evaluation of pesticides, it has been emphasized that there is no significant difference between organically and conventionally produced honeys [47]. In northern Italy, in the analysis of conventional and organic animal meat and milk samples for organochlorine pesticides and PCBs, pesticides and PCBs have been found below legal limits in both organic and conventional samples [6]. In another study conducted in Italy, the residues of persistent pollutants and pesticides were determined by GC-MS/MS analysis in most of the 59 organic honey samples. However, levels were below the MRL. This result was attributed to geographical conditions [48]. According to the findings of the United States Department of Agriculture (USDA) pesticide data program (PDP), the market place surveillance program of the California Dept. of Pesticide Regulation (CDPR) and a Consumers Union private residue-testing program, conventional/organic pesticide residue ratios have been found as 3.2, 4.8 and 2.9, respectively. These results seem to relieve the 70% of people who prefer the consumption of organic products to avoid from pesticides [49].

2.5. Veterinary drug residues in organic animal products

Outdoor rearing of animals in organic livestock production system may increase the risk of animals to contact with environmental pathogens that cause foot diseases (especially in pigs) as well as infectious diseases and helminthiasis. Lack of use of the curative and preventive conventional medicines (antibiotics) in organic farming leads to concerns about the treatment of the diseases. Mastitis is one of the most common diseases seen in dairy animals. Mastitis incidence is reported to be higher in organic production than in conventional production in England, Germany, to a lesser extent in Norway, Sweden and Denmark. However, it has been indicated that the difference between conventional and organic farming is decreased with the increasing awareness of animal production [4]. Since the use of veterinary drugs has not been allowed in organic livestock production, screening organic animal products for veterinary drug residues is at negligible levels. However, in a study conducted by Ghidini et al. [6], the antibiotic residues have been found at low levels, approximately 0.3%, in milk. In a study conducted before 1997, no difference was reported between conventional and organic honey in terms of veterinary drug residues [47]. In the analysis of kidney and meat samples of organic pigs (n = 20) taken from slaughterhouses, solely one sample showed a slight bacterial inhibitory effect against macrolide antibiotics. All of the organic and conventional eggs were found negative by the analyses for toltrazuril aminoglycosides, sulfonamides, beta-lactam antibiotics, tetracyclines, quinolones and colistin residues [13].

3. Contaminants in conventional foods

Developments in medicine, industry and agriculture have caused the world's population to increase and as a result of the need to feed the increasing population and urbanization, it became a necessity to produce more in agriculture and industry. This necessity caused widely use of different chemicals (pesticides, heavy metals, veterinary medicines, etc.) in various areas of production and this caused high amount of disposals of wastes in an uncontrolled manner to the environment, which results pollution. In parallel with the increase in pollution, the contaminants in food resources caused significant health problems in humans as a result of food chain [50].

3.1. Metal residues in conventional animal products

Heavy metals are the elements with an atomic weight between 63,546 and 200,590 and with a specific gravity more than 4.0 [51]. Metals are dispersed in the nature through geological and biological cycles [52] and then can penetrate to the food chain by contaminating the cereals from the environment, the animals and animal products from contaminated cereals and herbs, and fish from the polluted waters [52, 53].

Metals have harmful effects on most of our organs due to their elementary structure and their affination with organic ligands through biological cycles. Since metals are strongly bound to tissues, they are disposed very slowly and accumulated in the body. Samples of blood, urine and hair are usually used as indicators in evaluating the level of exposure to metals [52]. Although soil is the primary source of toxic metals in edible plants, the level of contamination increases more with metal wastes, consumption heavy metal wastes, leaded fuels and paints, fertilization of soil, animal fertilizers, sewage wastes, pesticides, irrigation with waste water, wastes of coal burning, spillage of petrochemicals, atmospheric accumulation, volcanic activities, etc. [54, 55]. It was revealed in the study of International Atomic Energy Agency (IAEA), which was conducted on various food samples taken from 12 countries, that Pb, Cd, Hg and As are important in terms of health and contamination risk, whereas antimony (Sb), Fe, Cu and Zn are less important [56]. International Agency for Research on Cancer (IARC) has specified Cd and Cd components as Group I carcinogen for human health (they induce lung tumors) [57]. Heavy metals, such as As, Cd, Hg, Cu, Pb, etc. that contaminate water through any means can accumulate within fish and then cause health problems in humans [58].

Maximum limits of Cd, Pb and Hg in some animal products are given in European Commission (EC) and Turkish Food Codex (TFC) [56]. There is also information about daily consumption amounts of metals that humans can take. Daily consumption amount of Sb is specified as 0.25–1.25 mg for children in the USA. The USA has determined that Al consumption should not exceed 12–14 mg/day for young and adult men and 9 mg/day for young and adult women [52]. Although, Zn is an essential element for human body, according to animal experiments, high doses of Zn is toxic and carcinogenic [53, 59]. The amount that can be taken with food is set as 0.23 mg/kg/day by the FDA [59]. Contaminated seafood with industrial wastes may contain high level of Zn, and entry of these products into the food chain can pose a danger to human health. Food and Agriculture Organization (FAO) and World Health Organization (WHO) and has determined that maximum amount of daily allowable consumption of as should be 2 μg/kg of body weight [60].

Most of the foods other than fish contain <0.25 mg/g As, but many fish species contain As between 1 and 10 mg/g. However, the amount of As found in marine crustaceans and deep sea fish was found as 100 mg/g or more [51]. Although the amount of As consumed is 10–200 μg/day, this amount can reach to several thousand μg/day in those that consume fish a lot in their diet [58]. The accumulated amount of As is 3–10 ppm in oyster, 42–174 ppm in mussels and 42–174 ppm in shrimps. Thus, most of the As taken with food by human is originated from sea foods [51]. However, As poisoning due to consumption of animal products is also possible. It was seen in early summer of 1955 that the babies younger than 12 months in western Japan had symptoms of anorexia, skin pigmentation, diarrhea, vomiting and distention and more than 100 babies showing these symptoms died and then it was found that the case was caused by consumption of powdered milk (popular and brand), which contains approximately 21–34 μg As per gram and As was found in the babies that consumed this powdered milk. It was also found that the origin of As was disodium phosphate, which was added to cow milks as a stabilizer [51, 61].

Cadmium, one of 25 substances that have a certain potential of danger against human health, cannot be disposed from and is accumulated within the body [57]. Foods usually contain Cd less than 0.05 ppm. However, WHO announced that the highest level of Cd was found in crustaceans as well as the kidneys of various animals, such as cow, chicken, pig, sheep and turkey as a result of analyses. Daily tolerable amount of consumption of Cd is 1 μg/kg of body weight [52]. The US Environmental Protection Agency (US EPA) stated that Hg and Hg components, which cause kidney cancer in experimental animals, may also cause cancer in humans [53]. The amount of Hg ranges between <1 and 50 μg in many food and beverage. However, the most important source of Hg in diet is the fisheries, caught from contaminated waters. Since crustaceans, such as mussel and oyster, feed by filtering water, they accumulate Hg components in their bodies. Mercury exists in bigger fishes in higher concentrations, compared to smaller ones. According to a research conducted by FDA, the amount of Hg in big tuna fishes was 0.25 ppm, whereas it was found as 0.13 ppm in average in smaller tuna fishes. The type of Hg that is found most in sea foods (>90%) is methyl mercury. FDA determined maximum allowable level of Hg in fish and crustaceans as 0.5 ppm [51]. Methyl mercury poisoning or Minamata disease, seen in Japan in 1954, is the most important example of Hg poisoning due to animal products. This disease was caused by consumption of fishes, living in water that was heavily contaminated with industrial wastewater. Similarly, serious muscle and neurological dysfunctions were seen in humans living in the city of Nigata and close to Minamata Bay in 1970 and 50 of 120 hospitalized persons died [51, 62].

3.2. Pesticide residues in conventional animal products

Pesticides are chemicals, most of which are highly toxic and are used against pests. These substances are toxically effective not only against pests but also other living organisms. Pesticides cause behavior disorders, immunosuppression, allergic reactions, estrogenic, teratogenec, mutagenic and genotoxic effects on living organisms. The duration of stay of pesticides in the natural environment, depend on their chemical structure. Pesticides, such as chlorinated hydrocarbons are resistant against biological degradation and they can stay in soil for years and penetrate to the food chain through various means. These fat soluble pesticides can be accumulated in the fat tissue of humans and animals as well as in their livers, kidneys and neural systems. Residues in the body of lactating animals can easily penetrate to the animal's milk [51, 52]. Contamination of animal products, such as meat and milk, with permanent pesticide residues is a frequently encountered problem. In a study conducted in Jordan, in which eggs as well as meats of chicken, sheep and cow were scanned for OCP residues, it was found that 28% of eggs, 20% of chicken meat, and 49% of red meat were contaminated with OCP [63].

Chlorinated compounds, such as PCBs, aldrin, DDT, DDD, DDE, BHC, heptachlor, etc., which enter the body of fishes through various means, can accumulate within the fishes and cause health problems in humans that consume these fishes. There is a linear relationship between accumulation of chlorinated compounds, such as PCBs, within fishes and their fat contents. The experiments showed that half-lives of PCBs in fishes are quite long. Despite the fact that utilization of PCBs was banned, they were still found in fish samples, analyzed in Ontario, Canada in 1992–1993, and in fish samples collected from 15 different countries in 1994–1995 [58].

3.3. Bacterial contaminants in conventional animal products

Milk is considered sterile (free from microorganism) because of its compounds and chemical properties. But milk is a suitable medium for most microorganisms. In general, it is not expected that milk has microorganisms and toxins unless there is a systemic or local infection. But clinical and subclinical mastitis, which are associated with local or systemic infections are common problems for animals [64, 65]. The milk flora of dairy animals consists of lactic acid bacteria (LAB; *Lactococcus, Lactobacillus, Leuconostoc, Streptococcus, Enterococcus* spp.) [64]. *Staphylococcus aureus*, which produces toxins like Staphylococcal enterotoxins (SEs), SE-like toxins (SEI) and toxic shock syndrome toxin (TSST-1) and is primarily responsible for foodborne poisonings, mostly exists in milks of animals with mastitis [65]. According to State Agencies to Centers for Disease Control and Prevention and from the Center for Science in the Public Interest Database, product-based numbers of *Campylobacter*-based cases caused by consumption of raw milk, pasteurized milk and cheese that's produced from raw milk between 2000 and 2006 were recorded, respectively, as 33, 1 and 3; numbers of *E. coli*-based cases were recorded, respectively, as 6, 0 and 1; numbers of *Salmonella*-based cases were recorded, respectively, as 1, 3 and 3 [66]. In a study that was made in Ankara (Turkey) with milk collected from street mostly found *S. aureus* > *E. coli* > *Klebsiella* > *Serratia* > *Proteus* [67]. In a study conducted in Czech Republic, total amount of mesophilic bacteria-TMBC ($\times 10^3$ CFU/ml) in conventional milk was found as 19 ± 16 (as Mean ± SD; n:1168) and amount of coliform bacteria-CBC ($\times 10^1$ CFU/ml) was found as 48 ± 36 (as Mean ± SD; n: 473) [21]. In low input farms in Brazil, bulk milk bacteria count (BMBC) was found higher in winter 2174 ± 958.4 (Mean ± SEM) according to other seasons. But in same season bulk tank somatic cell count (BTSCC × 1000 cells/ml) was found as 469 ± 113.4 (Mean ± SEM) [68]. In a study with raw milk in winter and summer In Slovenia, total bacteria count was found higher than 100,000 cfu/ml [69].

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3.4. Fungal contaminants and mycotoxins in conventional animal products

Mycotoxins are very toxic compounds that are produced by fungi and yeast [70]. Diseases due to the consumption of contaminated food with mycotoxins and molds are known worldwide. Grain and milk products are the most sensitive ones to contamination with mycotoxins among foods [71]. In mycotoxicosis cases, consumption of animal products (milk and dairy products, meat and meat products, egg, liver, kidney) has a major role as well as consumption of grain and grain products. Mycotoxins cause respiratory and neurological disorders, cancer, nephrotoxicity and hepatoxicity. Diseases such as Alzheimer's, multiple scleroses, etc. are considered to be related to mycotoxicosis. In pregnant women, mycotoxins that are taken with contaminated products can affect baby through placenta. Especially, infant and children are very sensitive to mycotoxins [72]. As a result of research in infant foods (rice flour, grain flour and milk powder) *Aspergillus* spp. (5%), *Penicillum* spp. (13%), *Mucor* spp. (5%) and unidentified species were isolated [71].

First mycotoxin (aflatoxin M1) contamination in dairy products was recorded in 1960s. Aflatoxin M1 (AFM1) is a metabolite of aflatoxin B1 (AFB1) and it forms in liver. 0.3–6.2% of AFB1 in animal feeds is metabolized, biotransformed, and secreted in milk in the form of AFM1. Mycotoxins such as OTA, zearalenone (ZEN), T-2 toxin and DON were also detected in milk. But these are not taken into account in importance as much as AFB1. One of the main reasons of DON and ZEN contamination is silage that is added into animal food [70]. Contamination with fungi and mycotoxin formation are not necessarily related to each other. Even when fungi contamination and variety is high mycotoxin can form less. According to a research in infant foods aflatoxin was detected only in 2.4% (19–70 μg/kg) of specimens despite of high fungus contamination [71]. In the European Union and some other countries accepted limits of AFM1 varies for raw milk is between 0.05 and 10 μg/kg, for dairy products is between 0.02 and 10 μg/kg [70].

In a study where fungal contamination variety's being analyzed of cow, goat and sheep milk, turned out that cow milk samples the highest diversity, and it was recorded that identified species were belonged to *Aspergillus, Chrysosporium, Cladosporium, Engyodontium, Fusarium, Penicillium* and *Torrubiella* genera [73]. There are less yeast and mold in raw milk than LAB [64]. In a study conducted in Slovenia, 95.0% of raw milk that was collected during winter and summer contains yeast and 63.3% contains molds. Isolated mold strains were identified as *Geotrichum* (51.5%), *Aspergillus* (33.8%), *Mucor* (5.9%), *Fusarium* (2.9%) and *Penicillium* (2.9%) genuses [69].

Poultry meat can also be contaminated by mycotoxins. A study showed that most common mold genuses are *Aspergillus* (58%) and *Penicillium*. Also, many other fungus genuses had been found with low incidence [74].

3.5. Contaminants in conventional animal foods from packaging material

Packaging is an indispensable part of the food production process. Today lots of plastics are being used as packaging material. Also, antioxidants, stabilizers, lubricants, antistatic and antiblocker materials can be used to increase the performance of package material. Additives, monomers, oligomers and contaminants can get transferred to food from packaging material. There are concerns about plasticizers (phthalates), thermal stabilizers, slip additives, light stabilizers, antioxidants, melamine, styrene, vinyl chloride, bisphenol A diglycidyl ether, isocyanate, caprolactam, polyethylene terephthalate oligomer, decomposition products, benzene and other volatiles, environmental contaminants, processing agents and other contaminants getting transferred to food [75, 76]. Studies on contamination in milk products related to this issue are limited [76].

Especially heavy metal pollution can occur in canned milk products and this is related to storage temperature and duration [77]. Also heavy metal pollution can occur during packaging process. As a result of a study, high amount of Pb was detected on bread packages [78]. In another study, high amount of Pb was detected on candy packages, which children consumed often, and this result was backed up by FDA [79, 80].

Because of that Cd got high dissolution in organic acids, human food chain's Cd pollution is very common. Studies showed that Cd, which is used for making food packages, can get transferred to high-acidic foods by getting dissolved. Wrapping foods with antimony foil, keeping in antimony containers and cooking in them causes foods get contaminated with high amount of Sb [51, 52]. Zinc can get transferred through galvanized containers to humans [56].

3.6. Veterinary drug residues in conventional animal products

Nowadays, various veterinary drugs and food additives are being used as therapeutic and prophylactic in animals. Foods of animal origin that contains drug residue consumed by human can cause allergic reactions, drug resistant microorganisms, toxicities in organs and tissue, hormonal disorders, teratogenic effects, etc. Animal originated milk and dairy products can contain veterinary drug residues as contaminants such as antimicrobials (like antibiotics), hormones, anthelmintics and pesticides. Beta-lactams, tetracyclines, aminoglycosides, macrolides and sulfonamides are the most commonly used antibiotics [81]. The result of a study made by USDA showed 5.3% of 529 carcasses have antibiotic residue. In these tests, chlortetracyclines, oxytetracyline, tetracycline, streptomycin, neomycin and erythromycin antibiotics had been detected [52]. In a study conducted in Croatia, 1259 raw milk samples were analyzed for antibiotic residue (chloramphenicol, penicillins, cephalosporins, tetracyclines, sulfonamides, beta-lactams, quinolones, aminoglycosides and macrolides) and 37 positive samples were found, but because of low levels it was stated that this would not cause any health problems [82]. The usage of chloramphenicol, which causes bone marrow suppression and aplastic anemia, is prohibited for animals. In Brazil where its usage prohibited in 1998, study made with ELISA showed 28.6% 84 raw milk samples were positive for chloramphenicol [83]. In Egypt, after antibiotic analyzes on broiler fillets, which were collected from markets, it turned out there were problems especially about detecting withdrawal times of oxytetracyline residues [84].

Steroid hormone can be in milk. Food production processes do not have any effect on milk and dairy products. Testosterone was detected in fresh cheese (0.1–0.5 mg/kg). Benzimidazole anthelmintics are being used commonly on animals thus benzimidazole anthelmintics and their metabolites (albendazole sulfoxide, albendazole sulfone, etc.) can be in dairy products [81]. The result of a study conducted in Macedonia analyzes showed only one of 55 bovine meat samples was positive for clenbuterol [85]. For preventing and curing diseases in fishes, veterinary drugs such as antibiotics mainly, anthelmintics and hormones are being used. Sometimes nonprescription or prohibited drugs can be used. In Canada, after analyzes made with sea, fresh water and canned fish, as ng/g level furazolidone metabolite 3-amino-2-oxazolidinone (AOZ), enrofloxacin, leucomalachite green, oxolinic acid and chloramphenicol residues were detected. In 28 eel samples, which were collected from markets in Tokyo, 0.07 ppm oxolinic acid was detected. Again in Tokyo, in flounder sample, which was collected from markets, 360 μg/kg oxytetracyline was detected on the skin [86].

4. The effect of various cooking and freezing processes on contaminants in animal foods

In the case of therapeutic drugs, before using the product, implementation of withdrawal time for the drug residues has been made mandatory. The obligation of drug applications to sick animals requires the disposal of the products containing residues of during this period, which means economic losses. Withdrawal time of drug residues in animal products is usually determined on unprocessed products. However, most of the animal products are consumed after certain treatments (such as cooking or storing in cooler at a certain time). Such processes may affect the drug residues in the products. Some previous studies have shown that processes applied to the product containing residue may result in changes in the level (quantity) of drug residues [87–90]. This suggests that, in inevitable conditions, the product containing residue is subjected to conditional consumption. Most of the researches on the subject are related to conventional animal products. The obtained results may vary depending on various factors such as quality of the animal products, the sample site on the same animal, the kind and duration of the applied processes. Studies have shown that tetracycline residues were decreased by 35–94% in muscle (cattle and sheep) and liver (cattle) through cooking (microwave, boiling, roasting, grilling and frying). Residues of penicillin (penicillin G-benzylpenicillin and cloxacillin) in milk have been reported to be decreased by the boiling and yogurt production (fermentation). On the other hand, since penicillinase released by microorganisms found in raw milk is deteriorated in the milk produced by UHT, benzylpenicillin is more stable (not disintegrated) in milk produced with this technique. Cooking cannot reduce the residues of oxolinic acid, flumequine, enrofloxacin and ciprofloxacin, which are belonging to Quinolone group, in fish. However, such residues can be removed by discarding the meat broth containing the residues, which are transferred into boiling water through boiling [87]. A similar situation has been observed in broilers concerning some drugs belonging to sulfonamides (sulfadiazine) and quinolone (danofloxacin) groups [88, 89]. Cooking decreases sulfamethazine residues in tissues (muscles and liver) of broiler at different rates. The most significant decrease occurs in boiling because during the boiling process drug in the tissue passes to water. Similarly, cooking (boiling and grilling, equally effective) may also be effective on sulfachloropyridazine-trimethoprim combinations in broiler tissues (muscle and liver) but these drugs cannot be transferred into boiled water in contrast to sulfamethazine [89]. Concentration of levamisole residues in broiler tissues (muscle, liver) can be diminished by different cooking processes (through disintegration and passing to water), whereas the effectiveness of deep freezing is time-dependent and the most losses occur on day 30th [90].

Especially washing as well as applications such as chlorine, chlorine dioxide, hydrogen peroxide, ozone, acetic acid, peracetic acid, hydroxy, iprodione can significantly reduce the pesticide residues in foods. Processes such as pasteurization, boiling, steaming and canning can reduce the levels of pesticide residues depending on the treatment type and time as in veterinary drug residues. In contrast, the implementation of food preservation techniques such as drying or dehydration increases the concentration of pesticides (due to a reduction in weight of product resulting from drying) [91].

Except the studies investigating the effects of processing on pesticide residues mostly in vegetables and cereals processing have diverse effects on pesticide residues in animal products such as milk (pasteurization) dairy products (cheese and yoghurt production) and eggs (boiling and scrambling). When reduction in pesticide residues in dairy products were compared, the reduction in foods made of sheep and goat's milk may be 50% less than in those made of cow's milk. Hexachlorocyclohexane (HCH) residues show a gradual decline by yoghurt production and by keeping at refrigerator [91]. Sausage making can lead to a significant reduction in organochlorine (hexachlorobenzene-HCB, α-, β-, γ-hexachlorocyclohexane-HCH and p,p'-DDE) pesticide residues [92].

Accumulation of organochlorine insecticides in fish is 10–10,000 fold higher than water [52]. Boling process is very effective in reducing DDT and heptachlor concentrations in dried fish (Bombay duck-loittya, ribbon fish-chhuri, shrimp-chingri, Chinese pomfret-rupchanda and Indian salmon-lakhua) [93]. It has been reported that frying process is effective in reducing α-HCH, β-HCH, γ-HCH, heptachlor, aldrin, heptachlor epoxide isomer B, pp'-DDE, endrin and pp'-DDT residues in commonly consumed fish (*Clupea harengus* L., *Salmo salar* L., *Cyprinus carpio* L., *Salmotrutta m. fario* L., *Platichthys flesus* L. and *Gadus morhua* L.) in Poland, and the most pronounced reduction is observed in β-HCH residues [94].

5. Legal regulation for foods of animal origin

Maximum residue limit (MRL) is defined as the highest concentration of a chemical residue that is legally permitted or accepted in a food, and acceptable daily intake (ADI) is defined as the amount of a residue that can be ingested on a daily basis over a lifetime without health risk [52]. National/international information concerning the maximum level of contaminants allowed in conventional product is available. Maximum levels for contaminants in conventional food of animal origin were determined by the EU. European Food Safety Authority (EFSA) makes risk assessment for pesticides and European Commission determines appropriate MRLs [95]. Food Additives FAO/WHO Joint Expert Committee (JECFA) determines the tolerable weekly intake levels of heavy metals in order to prevent heavy metal contamination in foods whereas EFSA and the Codex Alimentarius Commission (CAC) offer proposals for

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the exposure and tolerance limits of the heavy metals [50]. The EU directive No. 1881/2006 setting maximum levels for certain contaminants in foodstuffs entered into force following its publication in 2006. The MRLs in foodstuffs for nitrates, mycotoxins, metals, 3-monochloropropenes-1,2-diol (3-MCPD), dioxins and PCBs, polycyclic aromatic hydrocarbons (PAH) are specified in the relevant directive. The veterinary drug residue limits (MRLs) for a variety of foods including animal origin are determined by Committee for Medicinal Products for Veterinary Use (CVMP) of the European Medicines Agency (EMA) [95]. The first directive that concern to protect consumers from harmful substances coming from packaging materials was published by Commission of the European Communities (CEC) in 1976. Analysis methods for the official control of the vinyl chloride monomer levels in food packaging materials were identified in 1980. According to the regulations made by the EU, countries can make their own private arrangements at the national level [75].

The beginning of legal regulations on organic farming dates back to the 1970s. Studies conducted, independently, on organic farming in different countries became organized under a roof with the establishment of International Federation of Organic Agriculture Movement (IFOAM) that was headquartered in Germany in 1972. IFOAM is the first organization that defines the rules for ecological production worldwide. The rules, initially developed as the series of Basic Principles were modified as IFOAM Basic Standards, adopted by the General Assembly and entered into force in 1998 [96].

The first EU directive relevant to organic products was published on June 24, 1991. This directive, No 2092/91, was established solely for organic vegetable production [97]. In 1999, EU directive on animal production and general standards, "Codex Alimentarius", that was jointly prepared by the FAO and the WHO was published. The Codex Committee on Food Labelling, which was under CAC, lays down the standards pertaining to organically produced and labeled herbal and animal foodstuffs. Moreover, standards deal with plants and plant products, livestock and animal products, sources of animals, the prevention and treatment of animal diseases, such as fertilizer and pest management issues have been implemented [98]. In the following years, directives with different scopes and contents have been prepared and entered into force by the EU [97]. Directives issued by the EU are either accepted as they are by the countries of world or adopted according to their national conditions to create their own regulations.

The presence of any contaminant in organic products is normally not expected due to strict principles of organic farming. However, because some substances are the natural ingredients of the earth, they can be found naturally in organic products like happens in the elements (copper, iron, etc.). The levels of these substances in organic human and animal food (feed and feed ingredients) can vary depending on various factors such as geographical conditions and soil properties. On the other hand, despite the high precision of the organic farming, persistent environmental contaminants resulting from industrial and other activities can be involuntarily reflected in the organic products [99]. Legal regulations regarding the evaluation of organic products for contaminants are considered to be in their early stages. Although this situation varies among countries of the world, the EU seeks to create long-term control programs, especially, on pesticide residues with the issued regulations [100].

6. Conclusion

Food contaminants can cause consumer illness such as allergy, immunosuppression, cancer, teratogenicity, mutagenicity, genotoxicity. Therefore, monitoring of food contaminant is an important issue for the protection of public health. In order to protect public health use of many veterinary drugs for prophylactic purposes is prohibited by most of the countries. However, significant differences can arise among countries concerning the types of prohibited drugs and MRL values. This situation results in problems particularly for imported/exported products. On the other hand, there are still some veterinary drugs that have no MRLs for even conventional animal products. In addition, animal products may include environmental contaminants associated with industrial and agricultural activities. This situation raises concerns about the presence of residues/contaminants in animal products despite strict policy of the legal authorities. Therefore, people, especially in developed countries, tended to consume organic products. However, difficulties in production of organic products thus their high prices result in the consumption of them by only certain populations, which leads to social inequality in society. On the other hand, contamination may arise due to the failure to provide the required standard in organic products. Therefore, the regulative arrangements that are launched by the EU for organic products should be expanded and put into practice at countries basis as in conventional products.

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