ANALYSIS OF CONTAMINATION WITH HEAVY METALS AND POLYCHLORINATED BIPHENYLS OF BROILER COMPOUND FEED

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Abstract

In order to ensure food safety, it is necessary to consider all aspects of the food chain, from the primary agricultural production, including compound feed production, to the supply of consumers, as each of these can affect the safety of final products. The paper aims to determine the contamination with heavy metals and polychlorinated biphenyls of compound feed for broiler in different growth phases. Feed samples were taken during 2019 and 2020 from a feed mill representative for Romania in terms of production capacity (over 70,000 t/year). In 2019, for the analysed starter compound feed, quantifiable results were found for the content in Cd (0.146 ppm), Pb (1.6 ppm) and Zn (14.1 ppb); for finisher compound feed, positive values were identified for the content in Cu (10.6 ppm), respectively Zn (10.6 ppm). In 2020, quantifiable results for the concentration of As (0.2 ppm), Cu (13.4 ppm) and Zn (43.4 ppm) were identified for the finisher compound feed. Regarding the results of the analyses for the determination of the concentration in polychlorinated biphenyls (PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180, PCB sum) of compound feed, they were below the detection limit (2 ppb) for analyses performed in both years of study. Monitoring and analysis of chemical contaminants in compound feed can aid control and prevent contamination, with a direct impact on food safety, animal and human health.

Key words: compound feed, feed safety, heavy metals, PCBs

INTRODUCTION

Environmental pollution is a major global problem, which poses a worrying risk to human and animal health [19]. An increased risk of chemical contaminants or feed residues has been reported in the literature [13], [1]. It is now known that conventional agricultural activities and rapid industrialization are among the most important factors of environmental pollution [11].

Heavy metals such as copper (Cu), cadmium (Cd), chromium (Cr), lead (Pb) and arsenic (As) are potentially bioaccumulative toxic in the food chain, and can cause severe health problems even in low concentrations [2], [16], [4], [18].

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Although the contamination of heavy metal feeds cannot be completely avoided given the prevalence of these pollutants in the environment, there is a clear need to minimize this contamination in order to reduce both direct effects on animal health and indirect effects on human health [14].

Arsenic is a natural element, present in soil, groundwater and plants. Inorganic and organic forms of arsenic differ significantly in toxicity, with organic compounds having a very low toxic level. Consequently, the potential adverse effects of arsenic on animal and human health are determined by the inorganic fraction in animal feed or food [9].

Cadmium occurs naturally in the environment due to volcanic emissions and rock disintegration. In addition, anthropogenic sources have increased cadmium levels in soil, water and living organisms. Cadmium is released into the environment through wastewater, waste incineration and diffuse pollution of agricultural soils which is caused by the use of fertilizers that may contain cadmium in varying concentrations, depending on their origin [7]. Cadmium enters the food chain through air-water-soil, then directly, in animal organisms through air and water, or indirectly, through feed plants, which can accumulate on average 0.6 ppm, and in animal feed the concentration is even higher. Cadmium exists naturally in the animal body, since the fetal stage; it accumulates with age, as the half-life is very long, the total elimination in humans lasting about 20 years [23].

Lead can be found naturally in the environment, and the overall level of lead in the earth's crust is estimated at 20 mg/kg dry matter. Lead is produced naturally mainly in its inorganic form, as oxide or sulphur, but also as sulphate, carbonate and chromate [6]. Due to the fact that lead has no proven function in the body, it is considered as an element with obvious toxicity, being characterized essentially by its high binding capacity for various proteins and organic salts. Once inside the body, lead is retained by the renal cortex and liver, after which it is stored in bones in the form of phosphates. The circulation and retention of lead in the body are altered by the presence of ions (Ca, Fe), salts (iodine, phosphates), parathyroid hormone, vitamin D [23].

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), collectively referred to as 'dioxins', occur as a result of combustion processes as by-products in the manufacture of organochlorine compounds or as a result of the chlorine industry. Although dioxins are present only at very low levels in most plant raw materials used for animal feed, these chemicals bioaccumulate and bioamplify to higher levels in food [22].

Polychlorinated biphenyls (PCBs) are a group of complex substances, about 209 homologous isomers and 135 isomers of polychlorinated dibenzofuran. Both due to the solubility of lipids and the absence of an adequate metabolic pathway in organisms, PCBs tend to bioaccumulate along food chains. PCBs can affect the endocrine, nervous and immune systems. Feed is the main way of exposing farm animals to PCBs. The bioaccumulation of PCBs is related to the lipid content of tissues, especially fatty tissues, meat, liver, being transferred to milk and eggs. More than 90% of human PCB exposure comes from food of animal origin; PCB contamination of some pastures in northern Italy in the early 2000s is an example of the feed-food transfer chain [12].

MATERIALS AND METHODS

The research focused on determining the contamination with heavy metals and polychlorinated biphenyls of broiler compound feed. The analysed compound feed corresponded to the starter, grower and finisher growth phases.

In order to determine the contamination with heavy metals, the concentration of arsenic (As), cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) of starter and finisher compound feed was analysed.

To determine the contamination with polychlorinated biphenyls, the concentration in PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180 and PCB sum was analysed for starter, grower and finisher compound feed.

Feed samples were taken from a feed mill representative for Romania, with a total production volume of over 70,000 tons/year, during the years 2019 and 2020, and the analyses were performed in specialized laboratories from Romania, accredited RENAR (Romanian Accreditation Association).

Determination of heavy metal contamination (As, Cd, Cu, Pb, Zn) of compound feeds, had as standards: SR EN 14082:2003-Determination of trace elements. Determination of lead, cadmium, zinc, copper, iron and chromium by atomic absorption spectrometry (SAA) after calcination [24]; SR EN 14546:2005- Determination of trace elements. Determination of total arsenic by atomic absorption spectrometry by hydride generation (HGAAS) after dry calcination [25].

The determination of polychlorinated biphenyls (PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180, PCB sum) from the compound feed studied was performed according to the standard SR EN 1528-2: 2003 Fatty foods. Determination of pesticides and polychlorinated biphenyls (PCBs). Part 2: Extraction of fat, pesticides and PCBs and determination of fat content [26].

RESULTS AND DISCUSSIONS

In order to evaluate the concentration in heavy metals (As, Cd, Cu, Pb, Zn), determinations were made on samples of compound feed (starter, finisher), during 2019 and 2020, the results being presented in table 1.

Directive 2002/32/EC [5] established the following maximum permissible limits for the heavy metal content of feed intended for chickens: 2 ppm for As, 0.5 ppm for Cd, 5 ppm for Pb; EC Regulation no. Regulation (EC) No 1334/2003 [20] regulated the maximum permitted limits for Cu (25 ppm) and Zn (150 ppm) content.

Following the analyses performed in 2019 to determine the concentration in As and Cu of starter compound feed, the results were undetectable. To determine the concentration in Cd, the value of 0.146 ppm was obtained; this value was below the upper limit identified in the literature of 1.41 ppm [10]. For the Pb concentration of starter compound feed, the value found was below the upper limit found in the literature of 3.18 ppm [3]. For the Zn concentration in the starter compound feed sample, the identified value was below the lower limit found in the literature of 23.6 ppm [10].

Table 1 Results on the heavy metal content of compound feed (years 2019 and 2020)

Specification		Year 2019			Year 2020		
		n	Positive (%)	Results (ppm)	n	Positive (%)	Results (ppm)
Starter	As	1	0	nd	-	-	-
	Cd		100	0.146		-	-
	Cu		0	nd		-	-
	Pb		100	1.6		-	-
	Zn		100	14.1		-	-
Finisher	As	1	0	nd	1	100	0.2
	Cd		0	nd		0	nd
	Cu		100	10.6		100	13.4
	Pb		0	nd		0	nd
	Zn		100	10.6		100	43.3

n= number of samples analysed
nd= results as undetectable

For the analyses performed in 2019 in order to determine the concentration of As, Cd and Pb from finisher compound feed, the results were undetectable. To determine the Cu concentration of finisher compound feed, the identified value was below the upper limit found in the literature of 12.3 ppm [15]. The value found for the Zn concentration of starter compound feed was within the limit presented by the literature of 31.6 ppm [3].

Regarding the results of the analyses performed in 2020 to identify the concentration in Cd and Pb of finisher compound feed, they were undetectable. For the As concentration of the analysed feed samples, the identified value was below the upper limit specified in the literature of 2.37 ppm [10]. The Cu concentration of feed had a value identified below the lower limit found in the literature of 29.8 ppm [17]. For the Zn content of feed, was identified a value of 43.3 ppm, which was within the lower limit found in the literature of 54.3 ppm [15].

All the values obtained during the two years of study for the concentration in heavy metals (As, Cd, Cu, Pb, Zn) of the compound feed analysed, were below the maximum limit regulated by the legislation.

The results obtained for the determination of the concentration of polychlorinated biphenyls in compound feed for broiler are presented in table 2.

Table 2 Results on the polychlorinated biphenyls content of compound feed (years 2019 and 2020)

Specification		Year 2019			Year 2020		
		n	Positive (%)	Results (ppb)	n	Positive (%)	Results (ppb)
Starter	PCB 28			< LOD			
	PCB 52			< LOD			
	PCB 101			< LOD			
	PCB 138	2	0	< LOD	-	-	-
	PCB 153			< LOD			
	PCB 180			< LOD			
	PCB sum			< LOD			
Grower	PCB 28						< LOD
	PCB 52						< LOD
	PCB 101						< LOD
	PCB 138	-	-	-	1	0	< LOD
	PCB 153						< LOD
	PCB 180						< LOD
	PCB sum						< LOD
Finisher	PCB 28						< LOD
	PCB 52						< LOD
	PCB 101						< LOD
	PCB 138	-	-	-	1	0	< LOD
	PCB 153						< LOD
	PCB 180						< LOD
	PCB sum						< LOD

n= number of samples analysed
Limit of detection (LOD)= 2 ppb
PCB = polychlorinated biphenyls

As regards the legal basis, Directive 2002/32/EC of the European Parliament and of the Council [5] provides that any use of feeding stuffs containing concentrations of undesirable substances in excess of the maximum permitted levels is prohibited; on a scientific basis, a number of amendments have been made to this directive in order to update the maximum levels of undesirable substances in feed. The latest amendment setting out the maximum permitted limits for feed PCBs is EU Regulation no. 277/2012 [21]; it provides for raw materials of vegetable origin and for compound feed a maximum content of 10 ppb in PCBs (the sum of PCB 28, PCB 52, PCB 101, PCB 138, PCB 153 and PCB 180).

All results obtained during both years of study to determine the concentration of compound feed analysed in polychlorinated biphenyls were below the detection limit of 2 ppb, and implicitly below the maximum value allowed by law (10 ppb according to EU Regulation No. 277/2012) [21].

CONCLUSIONS

In the European Union, Directive 2002/32/EC [5] as subsequently amended and supplemented by the European Parliament and the Council set regulatory limits on undesirable substances in nutrients such as arsenic, cadmium, lead and mercury; regarding the maximum allowable feed limits of heavy metals represented by copper and zinc, these are regulated by EC Regulation no. 1334/2003 [20].

In a study by the European Food Safety Authority (EFSA) [8], six congeners (PCBs 28, 52, 101, 138, 153 and 180) were chosen as indicators for assessing the incidence of

PCBs. EFSA's Scientific Panel on Contaminants in the Food Chain (CONTAM Panel) noted in the Scientific Opinion on the presence of PCBs in feed and food that the sum of the six PCBs mentioned above accounted for about 50% of the total PCBs in food.

Regarding content in heavy metals (As, Cd, Cu, Pb, Zn,) in 2019, for the analysed starter compound feed, were found quantifiable results for content in Cd (0.146 ppm), Pb (1.6 ppm) and Zn (14.1 ppb); for the finisher compound feed, positive values were identified for the content in Cu (10.6 ppm), respectively Zn (10.6 ppm). In 2020, quantifiable results for the concentration in As (0.2 ppm), Cu (13.4 ppm) and Zn (43.4 ppm) were identified for finisher compound feed. All the results recorded were below the maximum limits imposed by law.

Regarding the results of the analyses for the determination of the concentration in polychlorinated biphenyls (PCB 28, PCB 52, PCB 101, PCB 138, PCB 153, PCB 180, PCB sum) of compound feed, they were below the detection limit (2 ppb) for analyses performed in both years of study.

It can be concluded that the monitoring and analysis of chemical contaminants in compound feed can aid to control and prevent contamination, having a direct impact on food safety, animal and human health.

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