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CADMIUM, LEAD AND ZINC LEVELS IN ORGANIC AND CONVENTIONAL EGGS

Gheorghe Valentin GORAN, Emanuela BADEA, Maria Lavinia BUGA, Victor CRIVINEANU

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Veterinary Medicine, 105 Splaiul Independenţei, 050097, 5th District, Bucharest, Romania

Corresponding author email: gheorghegoran@fmvb.ro

Abstract

The egg is considered one of the most nutritious animal origin foods, being a perfectly balanced source of protein, easily digestible fats, energy, minerals, and vitamins. Significant differences between organic and conventional eggs cover feed, medication, and animal welfare of hens. The study's purpose was the quantitative determination of Cd, Pb, and Zn from organic eggs and conventional eggs, and also from the organic feed. The heavy metals levels in organic eggs, conventional eggs, and organic feed samples were evaluated by AAS. Zn registered levels below the method's detection limit in organic eggs samples, and its levels were significantly lower compared to the maximum allowed level in EU for it in eggs, but higher compared to recommended levels in organic feed. Cd was significantly lower in organic eggs compared to their levels in conventional eggs. Pb registered significantly lower levels in organic feed, and Cd was higher compared to the maximum allowed level in EU for it in this type of feed. Conventional purchased eggs exceed the maximum EU allowed level for Pb and Cd.

Key words*: cadmium, lead, zinc, egg, AAS.*

INTRODUCTION

The egg is a very valuable food for man, because of its richness in nutrients that are indispensable to the body. The egg is a perfectly balanced source of protein, easily digestible fats, energy, minerals, and vitamins.

Nutritional differences between conventional and organic eggs are still controversial among scientists. Some studies have shown that organic eggs are not nutritionally superior, others, on the contrary, attribute to organic eggs qualities that conventional eggs do not have (Vincevica-Gaile et al., 2013; Filipiak-Florkiewicz et al., 2017; Lordelo et al., 2017; Mie et al., 2017).

There is no clear evidence in the literature that organic foods are significantly more nutritious than conventional foods. Organic food consumption can reduce exposure to pesticide residues and antibiotic-resistant bacteria (Smith-Spangler et al., 2012; Geng, 2018).

As in the other foods, in the eggs there may be found many substances that are potentially harmful to human health. In order to have safe products on the market, obtaining eggs for human consumption have to be done in units where management systems are implemented and the self-control program is respected (Petcu et al., 2007). Heavy metals increased distribution in the environment showed that the food safety and hygiene is very important, especially for eggs, due to their role in the daily diet (Savu and Petcu, 2002; Farahani et al., 2015; Sobhanardakani, 2017; Saad Eldin and Raslan, 2018).

The presence of heavy metals in the eggs may be due to the direct contamination, but mainly indirectly by poultry feed (Goran et al., 2010; ***, 2016). In the scientific literature, there are many studies on heavy metal residues in conventional eggs, but not on organic eggs or comparative studies of the level of heavy metals in these two egg categories.

For this reason, the study's main goal was the quantitative determination of cadmium, lead, and zinc by atomic absorption spectrometry (AAS) from organic eggs and conventional eggs, and also from the organic feed used for feeding hens from the organic farm.

MATERIALS AND METHODS

Samples preparation

Samples were represented by organic eggs (n=10) from an organic hen farm, conventional eggs (n=10) purchased from the supermarket in Bucharest, Romania, and premix-organic feed for laying hens (n=10) sampled from the same organic farms from which organic egg samples have been collected. Each egg was washed with ultrapure water and then its white and yolk were mixed together.

From each sample, the method EPA 3050a (EPA, 1996) was used to produce a transparent solution. For the samples digestion, a representative 1 g (wet weight) sample was digested with the repeated addition of nitric acid (HNO_3) and hydrogen peroxide (H_2O_2). The resultant solutions were diluted to a known volume with 0.01 $mol \cdot L^{-1}$ HCl. All reagents used were high purity pro analysis and calibration curves were developed using Merck standard solutions of Zn, Pb, and Cd.

Spectrometric analysis

Metal concentrations were directly measured by using an AAS (PerkinElmer AAnalyst 800), with hollow cathode lamps, equipped with air-acetylene flame, and graphite furnace. Mean recoveries for all metals ranged from 95 to 105%. The detection limits (ppm) were 0.05 (Pb), 0.005 (Cd), and 0.1 (Zn), respectively. Samples and blank solutions were measured in triplicates.

Statistical analysis

Statistical analysis was performed using the software of VassarStats: Website for Statistical Computation (http://vassarstats.net/). One-Way ANOVA was performed for all samples' mineral concentrations, and when ANOVA generated $p \leq 0.05$, means comparison was carried out by all-pair Tukey HSD Test.

RESULTS AND DISCUSSIONS

In this study, Cd, Pb, and Zn levels were analyzed in organic eggs and feed for laying hens from an organic farm, and in conventional eggs. The mean Cd, Pb, and Zn concentrations of eggs and feed samples from an organic farm of laying hens and conventional egg samples along with *p*-value resulting from One-Way ANOVA, are presented in Table 1 and expressed as *parts per million* (ppm).

Cd and Pb presented concentrations above the method's detection limit in all samples, and Zn registered levels below method's detection limit in all organic egg samples.

The highest mean concentration of Cd and Zn levels were registered in organic feed samples (0.883 ppm, and 1081.41 ppm, respectively). The highest mean Pb level was registered in conventional egg samples (0.342 ppm).

In both types of egg samples, organic and conventional, Cd recorded mean concentrations that exceed 0.05 ppm, which is the Maximum Allowed Level (MAL) for Cd in eggs.

Pb registered mean concentrations above the MAL (0.25 ppm) only in conventional egg samples. Zn mean concentration in conventional egg samples (2.77 ppm) registered significantly lower levels compared to MAL (20 ppm) for this element in eggs.

The comparison was made between the concentration of the same element in organic egg samples *vs* organic feed samples or in organic egg samples *vs* conventional egg samples, and not between different elements' concentrations.

Because Zn registered levels below the detection limit of the method, a comparison could not be made between its concentrations registered in studied samples.

In another study on eggs mineral content lower levels of Zn were registered compared to those registered in conventional egg samples in this study, and Cd and Pb were not detected in all egg samples (Goran et al., 2010).

The results of Cd and Pb contents (ppm) in egg samples registered in this study compared with their values in other studies are presented in Table 2.

Table 1. Mean Cd, Pb and Zn levels in eggs and feed samples (ppm)

Element	Organic eggs	Organic feed	Std.err.	Organic eggs	Conventional eggs	Std.err.	*p*-value
Cd	0.060	0.883	0.19	0.060 [a]	0.124 [b]	0.02	0.02
Pb	0.195	0.113	0.04	0.195 [a]	0.342 [a]	0.04	0.08
Zn	BDL**	1081.41	-	BDL**	2.77	-	-

*Levels not connected by the same letter are significantly different. The comparison can be made only between the concentration of one element and not between different elements concentrations.
**BDL - below method detection limit.

Table 2. Mean Cd and Pb levels (ppm) in egg samples compared with their values reported in other studies

Country	Pb	Cd	Reference
Bangladesh	1.06	0.08	Chowdhury et al., 2011
Belgium	0.009	0.0003	van Overmeire et al., 2006
Belgium	0.095	0.0005	Waegeneers et al., 2009
China	0.052	0.002	Zheng et al., 2007
Egypt c.e.*	0.18	0.09	Saad Eldin and Raslan, 2018
Egypt o.e.**	0.08	0.04	Saad Eldin and Raslan, 2018
France	0.01	0.0004	Leblanc et al., 2005
Greece	-	0.001	Giannenas et al., 2009
Iran	0.350	0.130	Salar-Amoli and Ali-Esfahani, 2015
Iran	0.29	0.18	Sobhanardakani, 2017
Italy	0.019	0.003	Esposito et al., 2016
Malaysia	0.420	0.054	Abduljaleel and Shuhaimi-Othrnan, 2011
Nigeria	0.590	0.070	Fakayode and Olu-Owolabi, 2003
Nigeria	0.80	0.18	Iwegbue et al., 2012
Pakistan	0.570	0.070	Khan and Naeem, 2006
Palestine	0.27	0.036	Abdulkhaliq et al., 2012
Romania	-	-	Goran et al., 2010
Turkey	0.06	2.34	Uluozlu et al., 2009
United Kingdom	0.24	-	Siddiqui et al., 2011
United Kingdom	0.003	0.0004	Ysart et al., 2000
Romania c.e.*	0.342	0.124	From this study
Romania o.e.**	0.195	0.060	From this study

*c.e. - commercial eggs
**o.e. - organic eggs

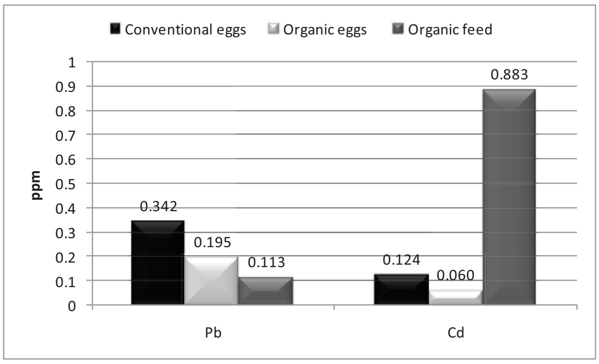

Figure 1. Mean Cd and Pb levels in egg and feed samples

In other studies on toxic metals, including Pb and Cd, no differences of concentrations in organic and conventional aliments have been reported (Mie et al., 2017).

Pb and Cd concentrations were higher in commercial eggs compared to organic eggs; the same pattern was registered also (Saad Eldin and Raslan, 2018). In this study, the same pattern in mean Cd and Pb levels was registered.

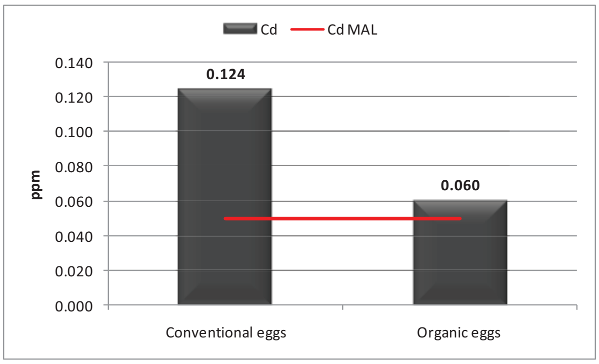

Figure 2. Mean Cd levels in egg samples

Environmental Cd pollution is mainly due to the use of this metal with special physico-chemical properties in different industries without the possibility of replacing it with

other less toxic metals (Goran and Crivineanu, 2016). In this study, the mean Cd levels registered in the analyzed samples were 0.06 ppm in organic eggs, 0.883 ppm in organic feed, and 0.124 ppm in conventional eggs, respectively (Figure 1). Organic eggs mean Cd level was significantly (p<0.05) lower compared to its level in conventional eggs.
The mean levels registered in this study are almost the same with the previous reports in Iran (Salar-Amoli and Ali-Esfahani, 2015; Sobhanardakani, 2017). The lowest mean Cd levels were registered in conventional eggs marketed in some European countries and China. Uluozlu et al. (2009) recorded the highest Cd concentrations (2.34 ppm) in conventional eggs marketed in Turkey.
Conventional eggs had significantly (p<0.05) higher Cd levels compared to organic eggs. In this study, in both conventional and organic eggs mean Cd levels exceeded the MAL decided by CE (CE, 2006) (Figure 2).

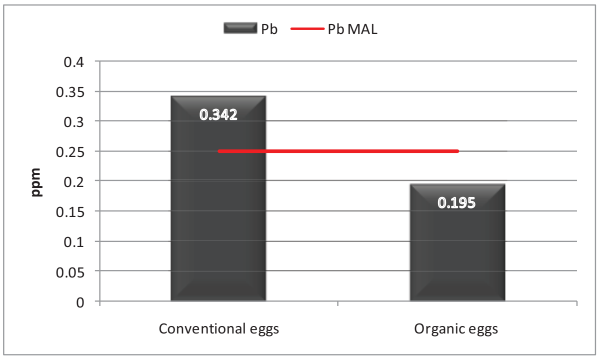

Figure 3. Mean Pb levels in egg samples

Similar to Cd, Pb mean levels were significantly higher in conventional eggs compared to organic eggs (Figure 3). Conventional eggs did not register significantly (p>0.05) Pb levels compared to organic eggs. The mean values of Pb concentrations in the analyzed egg samples were 0.342 ppm in conventional eggs, 0.195 ppm in organic eggs, and 0.113 ppm in organic feed, respectively (Figure 1). The recorded levels in this study were comparable with Pb levels found in egg samples in Iran and Malaysia (Abduljaleel and Shuhaimi-Othrnan, 2011; Salar-Amoli and Ali-Esfahani, 2015; Sobhanardakani, 2017). However, the highest Pb mean level (1.06 ppm) was reported in Bangladesh (Chowdhury et al., 2011).
Mean Pb levels registered in this study exceeded CE (CE, 2006) recommended concentration (0.25 ppm) in conventional egg samples (Figure 3).
Mean Cd and Pb levels in organic egg samples registered in this study were comparable with their levels found in egg samples in Egypt (Saad Eldin and Raslan, 2018).

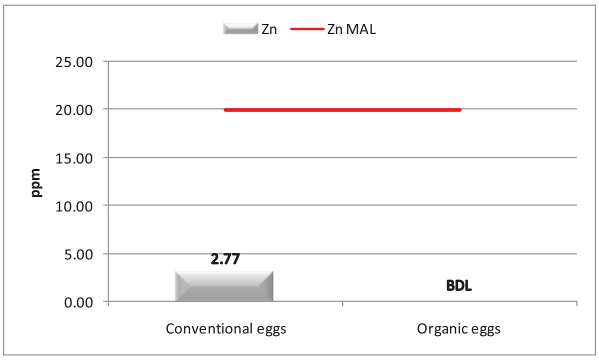

Figure 4. Mean Zn levels in egg samples
*BDL – below method detection limit

The Zn level for poultry diets, as recommended by the National Research Council, is between 40 mg/kg and 75 mg/kg diet (NRC, 1994). The 1000 ppm Zn supplement had no adverse effects on hen assesed parameters, and egg Zn levels increased linearly as dietary Zn levels increased (Kim and Patterson, 2005).
It can be easily observed that conventional eggs registered a significantly low mean Zn level compared to the MAL for this element in eggs (Figure 4).
The mean levels of Zn (ppm) in the analyzed samples were 2.77 and 1081.41 in conventional eggs and organic feed, respectively. The mean Zn levels in this study were lower compared to those reported in eggs (15.75 ± 4.05 ppm) analyzed in Italy (Esposito et al., 2016), and in Egypt (15.42 ± 1.03 ppm) (Saad Eldin and Raslan, 2018); lower mean Zn levels (0.046-0.166 ppm) were reported in eggs marketed in Pakistan (Islam et al., 2014).
Toxicological properties of Cd could originate from its chemical similarity to Zn (Aravind and Prasad, 2003), Cd and Zn having similar electronic configuration and valence and, hence, similar environmental properties. In

both plant and animal studies, the Cd-Zn antagonism was demonstrated.

In plants, it was observed that Cd is taken up by transporters for essential elements such as Zn and Ca (Ueno et al., 2004), which lead to a decrease of these minerals levels in the organisms. In another study, it was showed that higher Cd concentrations were accompanied by lower levels of Cu and Zn. (Zasadowski et al., 1999). In this study, the same pattern in Cd-Zn relationship was registered, the low levels of Zn were correlated to higher levels of Cd.

CONCLUSIONS

Zn registered levels below the method's detection limit in organic eggs samples, and its levels were significantly lower compared to the maximum allowed level in EU for it in eggs, but higher compared to recommended levels in organic feed.

Cd level was significantly lower in organic eggs compared to its level in conventional eggs.

Pb levels in eggs samples were not significantly different.

Pb registered a significantly lower level in organic feed, and Cd was higher compared to the maximum allowed level in EU for it in this type of feed.

Conventional purchased eggs exceed the maximum EU allowed level for Pb and Cd.

Thus, a continuous evaluation of heavy metals in all types of eggs as well as the feed is highly recommended, this being the main source of birds' exposure to these pollutants.

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