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Food and Environment: Trace Element Content of Hen Eggs from Different Housing Types

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Abstract

Eleven trace elements (Ba, Cu, Fe, Mn, Ni, Pb, Rb, Se, Sr, V, Zn) were quantitatively determined in hen egg samples collected from different poultry housing types (large-scale poultry farms, organic farms and domestic farms) over the territory of Latvia. Samples were wet digested and quantitatively analysed by total reflection X-ray fluorescence spectrometry (TXRF). The accuracy of analytical method was verified with analysis of certified reference material NCS ZC73017 (GSB-10)-Apple. The most variable range of concentrations and the highest content of elements were determined for hen egg samples derived from organic farms, while egg samples from domestic farms and poultry farms mostly contained lower content of elements. That can be attributed not only to poultry feed specifics within different housing types but also to the impact of environmental factors.

Keywords: Eggs; Environmental impact; Food composition; Latvia; Quantitative analysis; Trace elements; TXRF

1. Introduction

Hen eggs are important source of high quality natural proteins, as well as lipids, fatty acids, carotenoids, vitamins and essential minerals [1-3]. Chemical composition of eggs is complicated due to the presence of many organic compounds that can bind trace element ions, e.g., protein ovalbumin attracts Se, Hg, Zn, Cu, Mn, glycoprotein ovotransferrin and phosphoproteins bind Fe ions, but lipids of egg yolk can attract I, Cr, Ni and Zn [4]. Biochemical processes of avian organism requires such trace elements as Al, As, Co, Cr, Li, Mo,

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Ni, Si, Sb and V that can accumulate in avian organs and tissues if taken up in exaggerated doses by contaminated feed or from polluted environment. Poultry feed composition, which is different in various housing systems, may reflect to egg yolk and albumen elemental content [4, 5]. In case of food safety assessment it should be taken into account that all trace elements, including the essential ones, may become toxic if consumed in excessive amounts, or, contrary, may lead to element deficiency if present in human diet in insufficient amounts [6].

The importance of food analysis is strongly connected with consumer safety evaluation and in case of the research of poultry products such as eggs can be linked to the two main ways of contamination: (a) by microorganisms; (b) by chemical substances that can be transferred from environment into food chain. Hazards of chemical contamination mainly are associated with possible presence of persistent organic pollutants (*e.g.*, dioxin, polychlorinated biphenyls), pesticides (*e.g.*, DDT, aldrin, dieldrin) or potentially toxic metals (particularly, As, Hg, Pb, Cd, Cr) [7-9]. Widely applied agricultural practices, organic or conventional farming, differs with the restrictions of use of chemicals, however, products derived from organic farming have to be more healthy and less contaminated [10]. In general, element content of eggs may affect the avian embryogenesis and physical development, leading to quality errors of poultry products (eggs and meat), thereby causing contamination of food chain [4, 7, 11, 12].

The aim of the present study was to investigate quantitative content of trace elements in hen eggs produced in Latvia under the different conditions of poultry housing types and to estimate possible factors that influence element transfer into food chain.

2. Materials and Methods

2.1. Sample Collection

In total 33 hen egg samples were collected from different housing types of poultry farms in 2011-2012 over the territory of Latvia: from organic farms (organic farming was confirmed by certificate), domestic farms and large-scale poultry farms, see Figure 1.

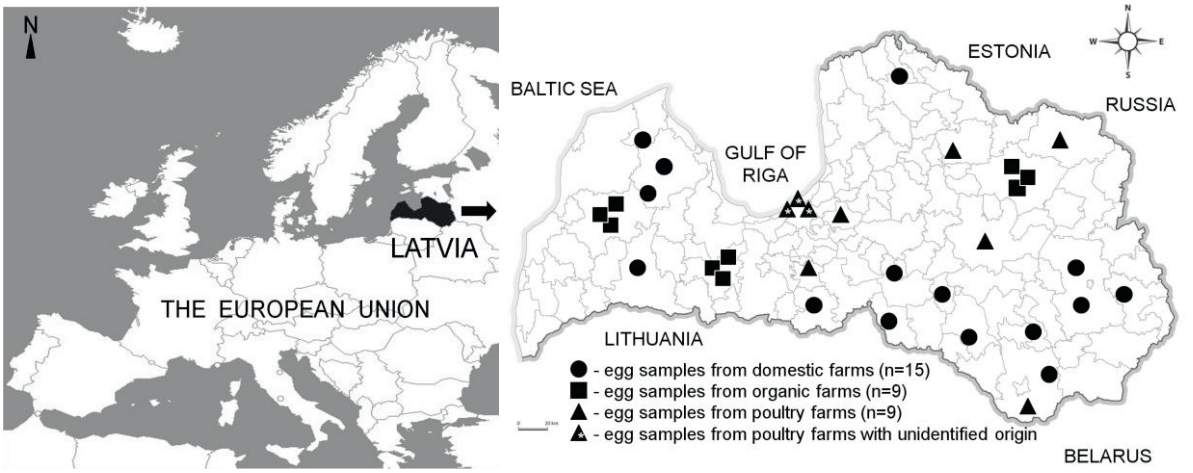

Fig. 1. Schematic map of the origin of analysed hen egg samples over the territory of Latvia.

Egg samples were purchased at the markets or derived directly at the farms. Conditions of the hens'

housing type were identified and recorded at the moment of sample purchasing. Within every sample five eggs were selected. Eggs were cleaned and carefully opened. Samples were homogenized, filled in disposable polyethylene bags, and stored frozen at -20 °C until the sample pre-treatment that was applied directly prior the analytical procedure. To avoid possible sample contamination no metal tools were used and the sample preparation was done by using chemically stabile plastic or glass equipment.

2.2. Sample Pre-Treatment

Pre-treatment of egg samples was done by wet digestion as widely described in literature [3] as follows: 1) 3.0000 g (±0.0005 g) of frozen egg sample was weighed on analytical balance in a glass beaker and left to attain the ambient temperature; 2) 10 ml of analytically pure concentrated H_2O_2 and 20 ml of analytically pure concentrated HNO_3 were added, and solutions were hold overnight; 3) dissolution was accelerated by heating at 160 ^oC until complete digestion; 4) solution was cooled, then quantitatively transferred into polypropylene test tube and filled up to 50 ml with ultra pure deionised water. Gallium solution (0.01 g l^{-1}) was added as an internal standard immediately prior analytical procedure by TXRF. Each sample was prepared in triplicate.

2.3. Applied Analytical Methods

Within the present study the quantitative content of trace elements was detected by using total reflection X-ray fluorescence spectrometer "Rontec PicoTAX" equipped with Mo cathode (50 kV and 1 mA), Ni/C reflector (level of reflection 80%), Be detector (area 10 mm^2, thickness 7.5 μm), and by applying the exposition time 1000 seconds. The accuracy of the applied analytical methods was verified by analysis of certified reference sample apple powder NCS ZC73017 (GBS-10)-Apple ("LGC Promochem").

2.4. Approach of Statistical Analysis

Box-whisker plotting was chosen as appropriate descriptive statistical analysis approach for the comparative assessment of the data sets of measurements. It allowed easy determination of the routine statistical values within the data ranges, as well as detection of the outliers was possible. Box-plots presented in the current study shows mean values of certain data sets, as well as range between 25th and 75th percentiles, while outliers are assessed as insignificant and are excluded of the figures.

3. Results and Discussion

Eleven trace elements (Ba, Cu, Fe, Mn, Ni, Pb, Rb, Se, Sr, V, Zn) were quantitatively determined in hen egg samples from different poultry housing types. The highest content was detected for Fe, Zn, Cu and Ba, see Figure 2.

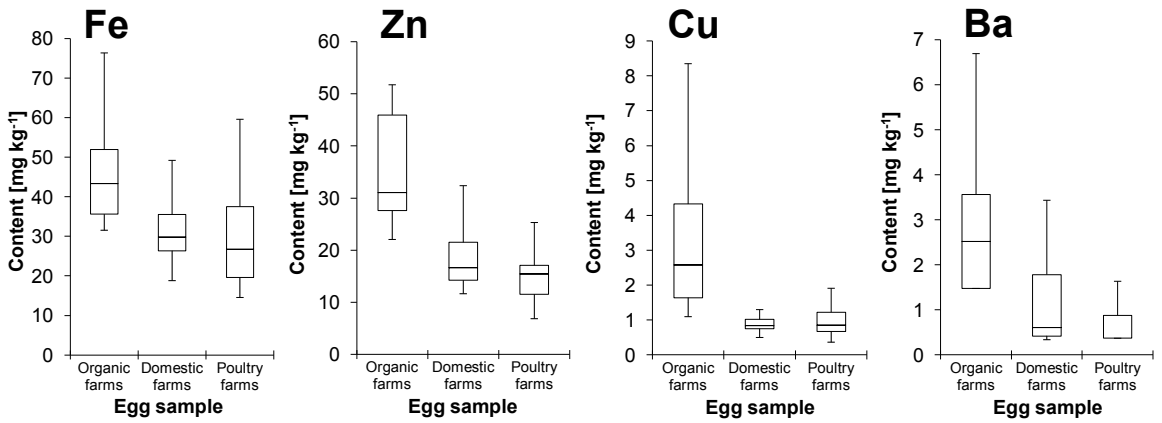

Fig. 2. Box-whisker plots of Fe, Zn, Cu and Ba content detected in hen egg samples derived from different poultry housing types.

Other elements (Rb, Mn, Ni, V, Sr, Pb Se) were detected in lower concentrations; in addition, Pb was not detected in any of egg samples derived from large-scale poultry farms, see Figure 3.

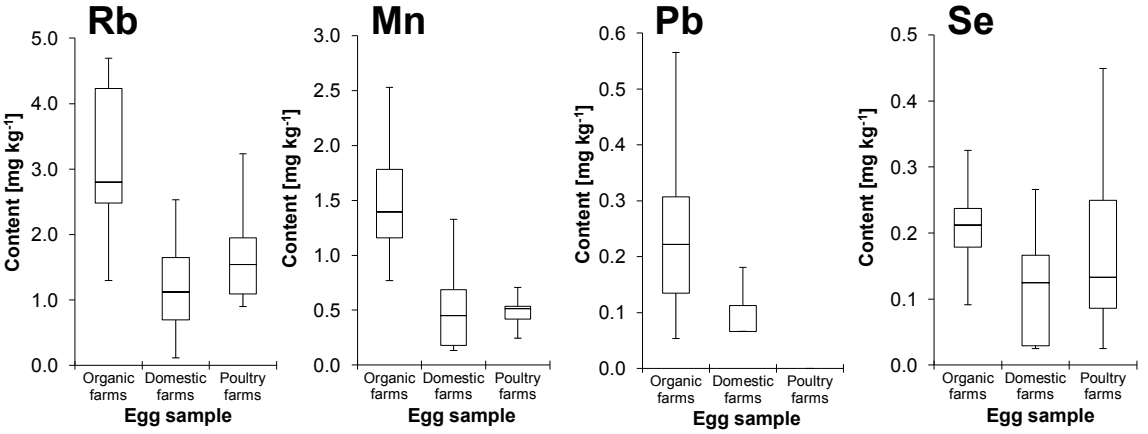

Fig. 3. Box-whisker plots of Rb, Mn, Pb and Se content detected in hen egg samples derived from different poultry housing types.

In all cases the highest mean values of elements were determined for egg samples derived from organic farms, while element content of eggs from domestic farms and poultry farms was lower and relatively similar. As it is known that organic farming is strictly controlled and use of chemicals is restricted within this agricultural practice [10], the results detected in the present study could not be associated with possible avian feed pollution of agricultural or veterinary chemicals, but might be connected with the impact of environmental factors on element content of egg samples, likely in relation to potential environmental contaminants (*e.g.*, Cu, Pb, Zn).

The differences between the hen eggs derived in different housing systems have been detected also in previous studies. For example, it has been discovered that hen eggs derived from poultry farms equipped with cage systems may have lower nutritional value and inferior taste compared to eggs from domestic farms and

organic farms. Feed, mineral supplements and water composition, as well as environmental impact such as indoor and outdoor conditions are assessed as the main influencing factors [4, 5, 7] that may lead to food chain contamination with potentially toxic elements. Holt *et al.* (2011) mentioned that hen eggs of free-range housing systems may become contaminated also through veterinary medicine that is given to protect hens against diseases and parasites [8].

Organic farming is known as more clean and healthy food production than conventional farming, but the obtained results within the present study regarding hen eggs are not in favour with this common assumption.

4. Conclusions

The present study revealed obvious differences between the trace element content of hen egg samples derived from different poultry housing types. The highest values and most variable range of concentrations of trace elements were determined for egg samples derived from organic farms, while egg samples from domestic farms and large-scale poultry farms mostly contained lower content of elements. That can be attributed not only to poultry feed specifics within different housing types but also to the impact of environmental factors such as indoor and outdoor conditions. Such environmental contaminant as Pb was not detected in egg samples from large-scale poultry farms where hen breeding is not affected by outdoor conditions. In general, the results confirmed the importance of the analysis of food composition that should be implemented by taking into account specific conditions of food production and applied agricultural practice. Influence of environmental factors may cause food contamination with potentially toxic elements that is the issue of high importance regarding consumers' safety.

Acknowledgements

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