БЕЗОПАСНОСТ НА ЯЙЦА ЗА КОНСУМАЦИЯ, ПОЛУЧЕНИ ПРИ КОНВЕНЦИОНАЛНА И АЛТЕРНАТИВНА СИСТЕМА НА ОТГЛЕЖДАНЕ НА КОКОШКИ НОСАЧКИ
TABLE EGGS SAFETY, AS INFLUENCED BY CONVENTIONAL AND ALTERNATIVE HOUSING SYSTEMS FOR LAYING HENS

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Резюме**

Европейското законодателство за благосъстоянието на кокошките носачки налага смяна на системата на отглеждане от конвенционална към алтернативна и следователно възниква необходимостта от изучаване на влиянието на тези системи върху производството на яйца. Проучено е изменението на качеството на яйцата по отношение на съдържанието на тежки метали и наличието на вътрешни дефекти при промяна на системите. В проучването са използвани 500 кокошки носачки от породата Кафяв лохман, разпределени в две групи на случаен принцип: група „C” са отглеждани в конвенционални клетки (250 кокошки), а група „N” – в подобрени клетки (250 кокошки). Двете групи са хранени унифицирано. На 28-седмична възраст (пик на носливост) от всяка група са взети за анализ по 100 яйца. Жълтъците и белтъците на яйцата са били подложени на атомна абсорбционна спектрометрия за оценка на съдържанието на тежки метали. Pb е било значително под допустимите нива (0,012 ppm). За другите метали са установени малко по-високи нива в жълтъците, произведени в конвенционалната система: Cd от 0,018 ppm (група „N”) до 0,021 ppm (група „C”); Cu – от 2,553 ppm в подобрените клетки срещу 2,617 ppm в конвенционалните. По отношение на Zn нивата при двете системи са сходни – 5,346-5,367 ppm. В белтъците са установени по-ниски нива на тежки метали в сравнение с жълтъците. Всички установени нива не са надвишавали токсичните граници за хора. Относно вътрешните дефекти повече кървави и месни петна са констатирани в яйцата, снесени в група „C”, където гъстотата на птиците е била по-висока.

Abstract

E.U. laws on laying hens welfare imposed the conversion of housing systems from conventional to alternative ones, hence the necessity to study the influence on eggs production. Qualitatively, we monitored the alterations in eggs content for heavy metals and the incidence of any internal defects, due to system switching. 500 Lohmann Brown hens were used as biological material, randomly allocated in two groups: C group-conventional cages (250 hens), N group-newly improved cages (250 hens), while layer diet was unique. 100 eggs produced during the 28th week of fowl life (laying peak) were sampled from each group. Yolks and albumens were submitted to atomic absorption spectrometry to assess heavy metals. Pb was below detection limit (0.012 ppm). For other metals, there were found slightly higher levels in the yolks produced in the conventional system: Cd from 0.018 ppm (N group) to 0.021 ppm (C group); Cu from 2.553 ppm in improved cages vs. 2.617 ppm in conventional ones. Zn levels were quite similar in both systems, 5.346-5.367 ppm. Lower levels of heavy metals were also found in albumens, compared to yolks. All levels did not exceed the toxicity limits for humans. As internal defects, more blood and meat spots occurred in the eggs laid in C group, where fowl density was higher.

Ключови думи: кокошки носачки, благосъстояние, яйца, тежки метали, кървави петна.
Key words: laying hens, welfare, eggs, heavy metals, blood spots.

INTRODUCTION

The data presented in several studies note that the issues raised by the use of a particular farming system (conventional, alternative, free-range, organic) on the final quality of products derived from poultry remains controversial, some studies favouring organic products, more especially for the sensorial qualities, while others favour the ones produced in the conventional technology systems as they can be more easily controlled against risk factors on food safety and for the nutritional value of the finished product.

Eggs internal quality could be assessed through many parameters, such as air chamber size, incidence of blood and meat spots, vitelline membrane elasticity and resistance, yolk and albumen integrity, pigmentation and viscosity, Haug score etc. Generally, is accepted that laying hens technology systems (nutrition, microclimate, housing etc.) could alter eggs quality. In successive studies, Abrahamsson et al., (1986), Abrahamsson and Tauson (1998) did not notice major differences related to eggs inner quality, under the influence of conventional and alternative farming systems for laying hens. More recent studies revealed decreased incidence of meat spots in the eggs issued from the free range system, compared to other rearing technologies (standard batteries, deep litter, organic farming (Hidalgo et al., 2008).

Besides eggs commercial quality, food safety is a high priority factor which should be in depth analysed, when several rearing systems for laying hens are compared. Chemicals that could threaten consumers' safety usually come from feedstuffs or fowl exposition to the organic persistent pollutants (dioxins and chloride biphenyl), pesticides and heavy metals from environment. These substances bio-accumulate across the food chain and are not totally inactivated in the polluted organisms. Chronic exposure to these products lead, on long term, to undesirable effects for consumers' health and organic resistance. Normally, the exposure is kept at low, controlled level, due to quality standards imposed for water and feed. However, a study revealed 2-6 times more heavy metals concentrations in free range eggs, compared to conventionally laid ones, due to the intense soil contamination with those pollutants (Van Overmeire et al., 2006). When antiparasitic aerosols are used in hens farms, the eggs produced in free range and enriched cages are safer in insecticide, compared to those issued from conventional batteries. The fact could be explained through the higher freedom of fowl movement in the alternative systems, hence the higher exposure to indoor pollutants in conventional cages, where hens are less mobile and more crowded (Olsen and Hammack, 2000). Thus, housing of laying hens within alternative systems does not compulsory lead to more contaminated eggs. Therefore, the subject remains controversial.

This paper emphasis on some results issued from wider researches which aimed to identify the ways in which the farming systems used in laying hens rearing, either conventional (accepted in the U till December 31st, 2011) ore alternative ones (compulsory in the EU since January 1st, 2012) affects the external and internal quality of table eggs or induce pollutants bioaccumulations in fowl organisms or their excretion into eggs.

MATERIALS AND METHODS

In order to run the experiment, 500 Lohmann Brown hens, aged 27-28 weeks, were randomly allocated in two experimental groups, as related to the used rearing system: C group-250 hens accommodated in conventional 3-leveled pyramidal batteries (vital space=400 cm^2/hen) and N group-250 hens accommodated in multileveled improved and furnished batteries (vital space=900 cm^2/hen, cages furnished with perches and isolated nest, apart from activity and rest areas). Hens were fed a diet formulated on the recipe appropriate to their age and production specialization. Each group has been housed in another farm, thus the origin of combined feed was different, while the nutritional values were identical.

Basing on a completely randomised design, 20 feed samples (100 g each) have been taken from every group, from different battery levels and areas, in order to assess an eventually presence of heavy metals within. The samples were then subjected to drying at 60°C, during 48 hours, until reached the intended level of moisture/dry matter then they were preserved through freezing.

One hundred eggs were sampled from each group to run internal quality inspection and to investigate an eventual occurrence of heavy metals contamination. Eggs were broken, albumens and yolks put apart and homogenised. One thousand ml of white and of yolk were withdrawn, then the remnants were mixed again together to establish the melange, which also gave 1000 ml sample.

These quantities of albumen, yolk and melange were introduced to force drying, at 60°C till reached a known level of moisture/dry matter, then minced and the issued powders were preserved through freezing, prior to their introduction to heavy metals analysing.

From every cryogenated sample of feed of eggs, there were randomly taken 10 samples weighing 1 g each. They were digested within acid environment (H_2SO_4, 96%), using a VelpScientifica DK20 digestion/desegregation unit, then distilled/condensed into a VelpScientifica TMD20 unit, according to the DIN 38414 method, as recommended by equipments manufacturer. The prepared samples were subjected to spectrophotometric analysis using a flame atomic absorption spectrophotometer, joined with a graphite oven, Aurora Instruments AAS 1200. the detection limits were of 0,012 ppm (mg/kg) for Pb; 0,016 ppm (mg/kg) for Cd, 0,006 ppm (mg/kg) for Cu; 0,020 ppm (mg/kg) for Zn and 0,016 ppb (µg/kg) for Hg, respectively.

Internal eggs quality was macroscopically inspected, after their breakage, to identify any unconformities, such as blood and meat spots, foreign particles etc. the results were expressed as percent from total analysed eggs/group.

Statistics and analysis of variance were computed for all acquired data, using the Data Analysis Toolpack in MsExcel software.

RESULTS AND DISCUSSION

The average values of heavy metals contents in combined feed, yolks, albumens and whole eggs are presented in table 1, for both studied systems.

In the conventional farming system, the highest heavy metals concentrations were analytically identified in the combined feed, especially for Pb (0,106±0,007 mg/kg), but its transferability in eggs could not be quantified, using the spectrophotometer detection limit. Thus, it was fulfilled the compliance with the EC Regulation no. 1881/2006, which stipulates a 0,020 mg/kg tolerable limit for aliments intended for human consumption. For Cadmium, although the detected level in feed was 3 times lower (0,035±0,004 mg/kg), compared to that measured for Pb, approximately 8,6% passed into albumen composition (0,003±0,001 mg/kg), and environ 60% in yolk (0,021±0,005 mg/kg) or, overall, 70% in melange-whole egg (0,025±0,004 mg/kg) (fig. 1).

In all situations, Cd level from eggs or edible compounds were situated below the tolerable limit, specified by the EC Regulation no. 1881/2006 (0,050 mg/kg). Levels of 5,06±0,123 mg/kg were found for Cu, respectively of 19,30±0,575 ppm for Zn, while Hg was below the detection limit, thus considered absent from fed or eggs.

The transfer of these contaminants in egg or in its edible compartments apart was realised, for Cu, almost integrally (95,57%) or partially (35,77% in albumen and 51,72% in yolk). As absolute levels, there were excreted 4,836 mg/kg Cu, that meant 0,24 mg Cu/egg of 60 g. thus, for an adult consumer weighing 75 kg which consumes such an egg, Cu dosage would be 0,0032 mg/kg body weight, meaning approximately 32% of the daily toxicity level (0,01 mg/kg body weight/day), calculated for a continuous aliment ingestion throughout 14 consecutive days. Zinc values reached 5,930±0,099 mg/kg in whole egg, most of it through the yolk (5,367±0,108 mg/kg). A similar calculus for an adult consumer weighing 75 kg reveal a Zn uptake of 0,30 mg/egg of 60 g and consequently 0,004 mg/kg body weight, which represents 1,33 % of daily toxicity limit (0,03 mg Zn/kg body weight/day). The highest transfer from feed to egg was recorded for the Cooper (95,57%).

In the alternative housing system, which used furnished, improved cages, the highest concentrations in heavy metals were assessed for Cu (5,17±0,062 ppm) and Zn (19,65±0,180 ppm), hence high transferability into eggs. Despite these facts, heavy metals in white, yolk and whole eggs were detected under the upper tolerable limits, accordingly to EC Regulation no. 1881/2006. Thus, Cu

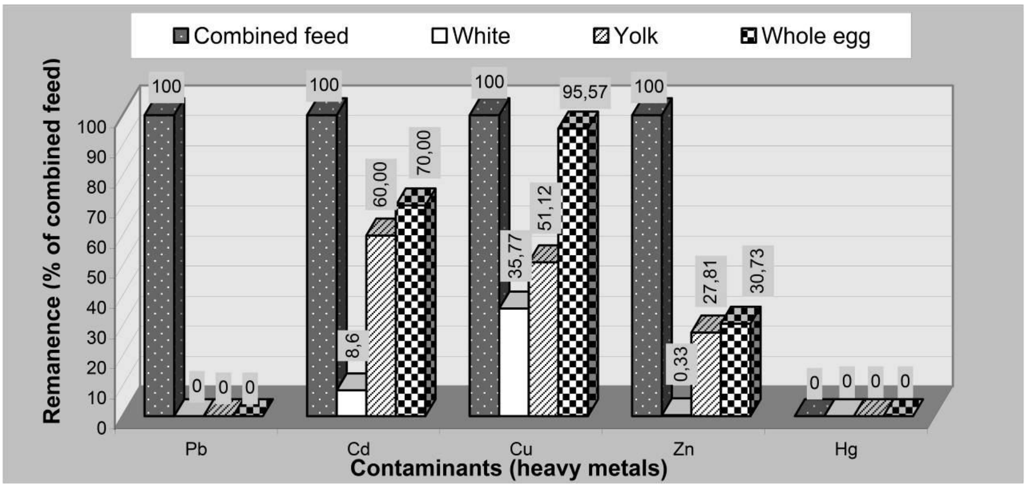
Таблица 1. Съдържание на тежки метали във фуража за кокошки носачки, отглеждани в обикновени и подобрени клетки и тяхното отлагане в яйцата

Table 1. Heavy metals in the diet used in feeding laying hens reared in conventional and improved cages and their reminiscence in laid eggs

Sample / Проби	Analysed heavy metal Тежки метали	C group (conventional system) / C група (конвенционална система)		N group (alternative system) / N група (алтернативна система)	
		$\overline{X}$	±StDev	$\overline{X}$	±StDev
Combined feed Комбиниран фураж	Pb ppm (mg/kg)	0,106	0,007	0,083	0,014
	Cd ppm (mg/kg)	0,035	0,004	0,034	0,011
	Cu ppm (mg/kg)	5,06	0,123	5,17	0,063
	Zn ppm (mg/kg)	19,30	0,576	19,65	0,180
	Hg ppb (μg/kg)	BDL*	-	BDL	-
Egg white В белтъка	Pb ppm (mg/kg)	BDL	-	BDL	-
	Cd ppm (mg/kg)	0,003	0,001	0,002	0,001
	Cu ppm (mg/kg)	1,810[b]	0,679	1,754[a]	0,734
	Zn ppm (mg/kg)	0,064	0,008	0,063	0,015
	Hg ppb (μg/kg)	BDL	-	BDL	-
Egg yolk В жълтъка	Pb ppm (mg/kg)	BDL	-	BDL	-
	Cd ppm (mg/kg)	0,021	0,005	0,018	0,008
	Cu ppm (mg/kg)	2,617[b]	0,190	2,553[a]	0,031
	Zn ppm (mg/kg)	5,367	0,108	5,347	0,081
	Hg ppb (μg/kg)	BDL	-	BDL	-
Whole egg В цялото яйце	Pb ppm (mg/kg)	BDL	-	BDL	-
	Cd ppm (mg/kg)	0,025	0,004	0,016	0,010
	Cu ppm (mg/kg)	4,836[b]	0,687	4,335[a]	0,371
	Zn ppm (mg/kg)	5,930	0,099	5,951	0,105
	Hg ppb (μg/kg)	BDL	-	BDL	-

*BDL – below analytical detection limit/по-ниско от прага на чувствителност

[ab]– different superscripts within row: statistically significant differences (p<0,05)/различията между стойностите в редовете са достоверни, достоверност P<0.05



Фиг. 1. *Ниво на тежки метали в яйца след приемане на замърсен фураж с известни нива на замърсяване (алтернативна система на отглеждане)*

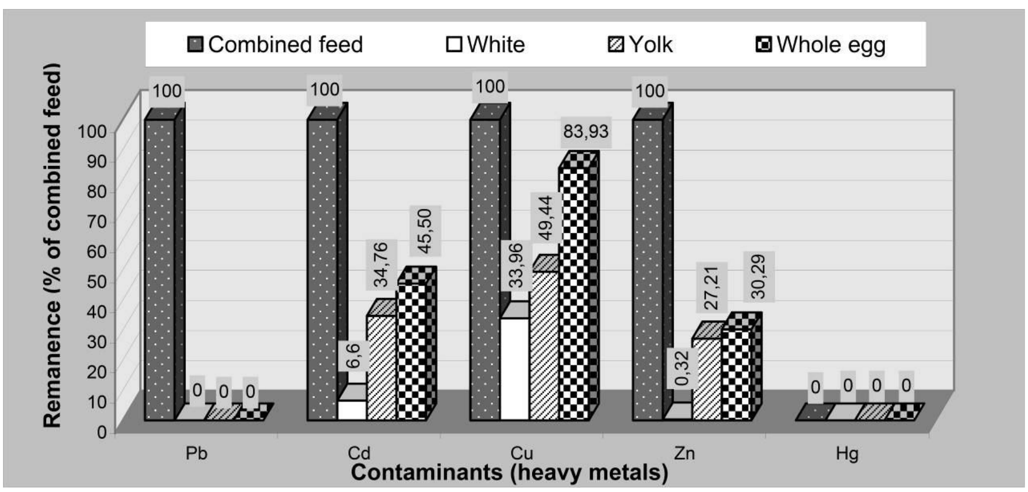
Fig. 1. *Resilience level of certain heavy metals in eggs, after the intake of polluted feed with known contamination levels (alternative farming system)*

transferred in eggs represented 29% of daily toxicity limit for an adult presenting 75 kg weight. Hg was not detected in diet, while Pb, which presented 0,083±0,014 ppm in feed, did not reach the egg.

In yolk, heavy metals were excreted in higher concentrations, compared to albumen, depicting thus the lipophilic predisposition of metallic ions, to be chelated with lipid micelle in nutritive vitellus. It was noticed that the highest transfer rate from feed to egg was met for Cu (83,93%), followed by Cd (45,50%) and Zn (30,29%) (fig. 2).

In both rearing systems, the avian organism acted as a veritable filter for lead residues, the excretion rate through eggs being practical null. Overall, heavy metals transfer in eggs was lower in the alternative farming system, due to certain statistically significant differences noticed in comparison with the conventional system ($p<0,05$), related to Cu residues in white, yolk or whole egg. This fact indicates that the standard system, where the vital space is less, thus fowl density is higher, induces a certain lack of comfort to birds and lowers their organism resistance, hence their reduced capability in “cleaning” certain pollutants from eaten feed.

The average values of combined feeds, white and yolk contents in heavy metals are shown in table 2, in comparison with the literature data. Thus, lead concentration in feed represented 6,8-12,2% (group N) or 8,69-15,6% (group C) of the maximum tolerable level, as specified by other authors (Albu, 2010; Albu et al., 2011) or 0,83-1,06 % of the limit imposed by European regulations (EC Reg 574/2011), respectively.



Фиг. 2. *Ниво на тежки метали в яйца след приемане на замърсен фураж с известни нива на замърсяване (алтернативна система на отглеждане)*

Fig. 2. *Resilience level of certain heavy metals in eggs, after the intake of polluted feed with known contamination levels (alternative farming system)*

Таблица 2. Средно съдържание на тежки метали в комбиниран фураж, използван при кокошки носачки, гледани в конвенционални или подобрени приспособления и сравнение на тези замърсители в снесените яйца по сравнение с литературни данни

Table 2. Average content in heavy metals of combined feed used for laying hens reared in conventional or improved batteries and the reminiscence of these pollutants in the laid eggs, compared to literature data

Sample Проби	Heavy metals Тежки метали	Comparative results						
		C group (convent. cages) С група Конвенционални клетки	N group (improved cages) N група Подобрени клетки	Bargellini et al., 2008	Polonis and Dmoch, 2007	Meluzzi et al., 1996	Albu A., 2010, 2011	Reg. UE 574/2011
Combined feed Комбиниран фураж	Pb ppm (mg/kg)	0,106	0,083				0,68-1,22	max. 10,00
	Cd ppm (mg/kg)	0,035	0,034				5,00	max. 1,00
	Cu ppm (mg/kg)	5,06	5,17				8,00	
	Zn ppm (mg/kg)	19,30	19,65				20,00	
	Hg ppb (μg/kg)	BDL*	BDL					max. 0,10
Egg white В белтъка	Pb ppm (mg/kg)	BDL	BDL			0,315		
	Cd ppm (mg/kg)	0,003	0,002					
	Cu ppm (mg/kg)	1,810	1,754					
	Zn ppm (mg/kg)	0,064	0,063					
	Hg ppb (μg/kg)	BDL	BDL					
Egg yolk В жълтъка	Pb ppm (mg/kg)	BDL	BDL	0,12	0,036	0,397		
	Cd ppm (mg/kg)	0,021	0,012	0,009				
	Cu ppm (mg/kg)	2,617	2,553	-				
	Zn ppm (mg/kg)	5,367	5,347	3,83				
	Hg ppb (μg/kg)	BDL	BDL	-				

*BDL – below analytical detection limit/по-ниско от прага на чувствителност

The same EU regulation specifies a maximal tolerable level of 1 ppm Cd in combined fees, while the analytical findings indicated a content of 0,034 – 0,035 ppm CD, thus 3,4-3,5 % of the critical limit.

Cu average content in feed was established at 5,06 ppm (C group) and at 5,17ppm (N group), which represents 63.25-64.63% of the maximal admitted limit for this microelement (8 ppm) (Albu, 2010; Albu et al., 2011).

The detection method did not quantify the presence of Hg, the situation falling thus within the European normative, which indicates a maximum Hg level of 0,1 ppb Hg in feed. However, the Zn level was assessed at a level close to the maximal tolerated one (Albu, 2010; Albu et al., 2011) (19,30 vs. 20 ppm, thus 96,5% in the conventional farm and 19,65 vs. 20 ppm, thus 98,3% in the alternative farm).

For eggs white, the literature indicates 0,315 ppm Pb (Meluzzi et al., 1996), while our analyses did not reveal this heavy metal occurrence.

It is known that most eggs pollutants have tropism for yolks because they (including here heavy metals) are more soluble and addictive for a lipids rich environment, easily oxidable, favouring thus the chelating of highly reactive metallic ions within the organic catena of phospholipids (Bargellini et al., 2008). Thus, in literature, value of 0,12ppm Pb (Bargellini et al., 2008); 0,036ppm Pb (Polonis and Dmoch, 1996) and 0,397 ppm Pb (Meluzzi et al., 1996) wee reported in yolk, while in the own findings, the heavy metal was found below the detection limit, both for conventional and alternative housing system.

For Cadmium, yolks analytical findings revealed higher concentration in N group (+33%; 0,012 ppm) and more than double in C group (0,021 ppm), compared to literature (0,009 ppm) (Bargellini et al., 2008). However, these levels did not pass over the upper admitted level for human consumers (2,5 µg Cd/kg body weight, according to EFSA, 2009). Same situation occurred for Zn content, the assessed values (5,347-5,367 ppm) passing 1,4 folds the ones reported by other authors (Bargellini et al., 2008).

The highest the brooding density in cages, the highest incidence of the eggs presenting internal defects in conventional batteries (23% eggs with meat and blood spots), compared to those measured in improved batteries (19% eggs with meat and blood spots).

CONCLUSIONS

1. For relatively identical heavy metals contamination in combined feed, the transfer o these pollutants in eggs was more intense in the hens accommodated in conventional cage batteries, compared to those whose welfare level was enriched, through their accommodation in dimensionally improved and furnished cage batteries.
2. Under all circumstances, the heavy metals content of the eggs was situated below the upper tolerable level of toxicity for human consumers.
3. The occurrence of internal eggs nonconformities was lower in the alternative studied technological system.

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*** Regulamentul (UE) nr. 574/2011 al Comisiei din 16 iunie 2011 de modificare a anexei I la Directiva 2002/32/CE a Parlamentului European şi a Consiliului în ceea ce priveşte limitele maxime de nitrii, melamină, Ambrosia spp. şi transferul de anumite coccidiostatice sau histomonostatice, precum şi de consolidare a anexelor I ş'i II Text cu relevană pentru SEE, accesat online la http://eur-lex.europa.eu/Result.do?T1=V1&T2=2011&T3=574&RechType=RECH_naturel&Submit=C%C4%83utare, la data de 03.07.2012

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