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Trace elements residues in the table eggs rolling in the Mansoura City markets Egypt

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Abstract

The residual concentration levels of copper (Cu), iron (Fe), lead (Pb), cadmium (Cd), and arsenic (As) in commercially and home-produced eggs of hen and duck rolled in Mansoura city marketes, Egypt were determined. Therefore, 80 egg samples were randomly collected from different grocery stores to be analyzed using Flame Atomic Absorption Spectrometry. The examined eggs samples comply the permissible limits for trace elements in table eggs except Lead which only 95% brown shell hen egg, 65% Baladi hen egg, and 85% duck egg were comply the their permissible limits. Cd and As could not be detected in all examined egg samples. Acceptable Estimated Daily Intake “AEDI” was calculated as 0.325 mg for Cu, 2.652 mg for Fe, and 0.020 mg for Pb which represented 0.93%, 4.74%, and 4.08% of Accepted daily Intake “ADI” (70 kg person). The findings indicate that the concentrations level of Cu, Fe, and Pb in Eggs in Mansoura city marketes are set within the Standard limits and considered as safe for human consumption. Two large eggs (100 g) consumption/ day cover the Recommended Daily Allowance “RDA” needed for the adult person/ day from Cu but in case of Fe, other source of iron should be added to his daily diet.

Introduction

Eggs are one of nature’s most nutritious and economical foods in the daily diet. Eggs are included in several food products for various functions. (Sharkawy and Ahmed, 2002; Leggli *et al*., 2010). Global environmental pollution with trace elements are leading to increase the investigations concerning metal contamination of food-stuffs including eggs, which represent an important part of humans’ diet, especially children (IDF, 1991).

Industrializations Progress throughout the world has been accompanied by the extraction and distribution of mineral substances from their natural deposits. Many minerals, especially trace elements, have undergone chemical changes through technical processes as finally pass, dispersed and in solutions into water and air and consequently into food chain.

Poultry could take up heavy metal compounds from different sources; metal residues may concentrate in their meat, and eggs (Nisianakis *et al*., 2009). Some trace elements are common in the diet and necessary for good human health. Iron (Fe) and copper (Cu) are essential trace elements which required by humans nevertheless, all metals are toxic at higher concentrations (Chronopoulos *et al*., 1997; Lane and Morel, 2009).

Other heavy metals as arsenic (As), Cadmium (Cd) lead (Pb) are toxic and their accumulation over time inside chicken can cause serious illness. Certain elements that normally toxic are beneficial for certain organisms or under certain conditions (Lane and *et al*., 2005). Heavy metals may cause acute or chronic toxicity of human. Intake of heavy metals through the food chain has been widely reported through the world (Muchuweti *et al*., 2006). Heavy metal toxicity can result in damaged or reduced mental and central nervous system functions, lower energy levels, and damage to blood composition, lungs, kidneys, liver and other vital organs (International Occupational Safety and Health Information, 1999).

Heavy metals have only become a focus of public interest science the analytical techniques have made it possible to detect them even in traces amounts. This has made it possible for toxicologists in animal experiments to follow up the effects of individual substances down to the smallest concentrations.

The accurate determination of trace metals in eggs is still an analytical challenge, due to their low concentration level and difficulties that arise from matrix characteristics. Therefore, this study was conducted to determine the residual concentrations levels of copper, iron, lead, cadmium, and arsenic in commercially and home-produced eggs of hen and

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duck rolled in Mansoura city, Egypt.

Materials and Methods

Samples collection

Hen egg samples, brown shell, white shell, Baladi, and duck egg samples (20 each) were randomly collected from different grocery stores at Mansoura city, Egypt. Samples were transferred in clean dry plastic bags to the laboratory where they were prepared for trace elements assessment.

Samples analysis

Each sample was initially prepared for detection of elements residues levels using pressure digestion technique as recommended by Kotz *et al.*, (1972). The analyzed technique were done using Flame Atomic Absorption Spectrometry (FAAS) " OBC Avanda Ver 1.33" (AOAC, 2006). Three replicates were done for more accuracy.

The acceptable daily intakes of Cu, Fe, Cd, As and Pb were calculated on the basis that the adult person (70 kg weight) consuming 100 g egg/day according to recommendations of Nutrition Institute (2006). The results were compared with those recommended by the joint FAO/WHO, Food Standards Programme, Codex Committee on Contaminants in Foods (Codex, 2011).

Statically analysis

Analysis of variance (ANOVA) was performed in all data using the Generalized Linear Models (GLM) procedure using SAS (1996).

Results and Discussion

Copper residues

The mean concentration levels of copper in brown shell, white shell, Baladi and duck eggs were 0.78, 6.32, 0.63 and 5.27 ppm respectively (Table 1). Cu concentration levels in evaluated samples were below the permissible limits (10 ppm) set by Zmudzki and Szkoda (1996). The mean Cu concentration levels were significantly differ ($P < 0.05$) in brown shell and Baladi eggs in compared to white shell eggs and duck eggs. The higher levels of copper residues in white shell eggs may be attributed to use of copper sulphate as a feed additive in the diet of laying leghorn chicken, which are the common producers of white eggs in Egypt. The higher level of Cu in duck eggs may be due to the common use of copper sulphate pentahydrate in the surface water for the control of algae, where ducks often swim and drink from (Codex, 2011).

The obtained results were higher than those

Table 1. Statistic analytical results of copper residues (mg/kg) in examined egg samples

Samples	No	Minimum	Maximum	Mean ± SE
Brown shell egg	20/20	0.14	2.06	0.78±0.14^{a}
White shell egg	20/20	0.6	9.74	6.32±0.96^{a}
Baladi egg	20/18	ND	1.98	0.63±0.11^{b}
Duck egg	20/20	0.63	9.58	5.27±0.85^{b}

^{a,b}: means with different superscript are significantly different at $p < 0.05$

Table 2. Statistical analytical results of Iron residues (mg/kg) in examined egg samples

Samples	No	Minimum	Maximum	Mean ± SE
Brown shell egg	20/20	1.24	99.11	30.041±6.791^{a}
White shell egg	20/20	2.30	35.76	13.963±2.871^{b}
Baladi egg	20/20	14.77	68.663	32.839±3.158^{a}
Duck egg	20/20	4.99	53.86	29.224±2.972^{a}

^{a,b}: means with different superscript are significantly different at $p < 0.05$

reported by the United States Department of Agriculture which set a limit of 0.72 ppm for Cu residues in egg (USDA, 2011). Cu concentration levels in brown shell and Baladi egg were comparable to those evaluated in eggs in Bangladesh 0.64 mg/kg (Chowdhury *et al.*, 2011); 0.60 mg/kg in Belgium (Van Overmeire *et al.*, 2006); 0.62 mg/kg in British eggs (Ysart *et al.*, 2000); 0.78 mg/kg in Nigeria (Fakayode and Olu-Owolabi, 2003); 1.02 mg/kg in Indonesia (Surtipanti *et al.*, 1995).

Gastrointestinal tract is the most sensitive target of copper toxicity. In human studies, involving a single exposure to copper following an overnight fast, adverse gastrointestinal effects (nausea, vomiting, abdominal pain, and/or diarrhea) were observed at doses of 0.011-0.03 mg/kg (Araya *et al.*, 2001; Gottdand *et al.*, 2001; Olivares *et al.*, 2001; Araya *et al.*, 2003a, Araya *et al.*, 2003b, Araya *et al.*, 2003c). The Minimal Risk Level of Cu is 0.01 mg/kg /day, which has been derived for acute-duration (1-14 days) oral exposure to copper (ATSRD, 2004).

Iron residues

The mean of iron concentration levels in brown shell hen eggs, white shell hen eggs, Baladi hen eggs and duck egg were 30.041, 13.963, 32.839, and 29.224 ppm, respectively. The average of Fe concentration levels in eggs according to the USDA is 17.6. ppm (USDA, 2011). Iron was significantly decreased ($P < 0.05$) in white shell hen eggs than the other types. The concentration level of Fe was higher than the average in brown shell hen eggs, Baladi hen eggs and duck eggs, and lower in the white shell hen eggs. High Fe

Table 3. Statistical analytical results of Lead residues (mg/kg) in the examined egg samples

Samples	No	Minimum	Maximum	Mean ± SE
Brown shell egg	20/3	ND	3.54	0.185±0.177[a]
White shell egg	20/0	ND	ND	ND
Baladi egg	20/12	ND	1.30	0.290±0.087[a]
Duck egg	20/5	ND	1.28	0.137±0.074[a]

a: No significant difference at $P < 0.05$
ND: not detected
Cadmium and arsenic couldn't be detected.

Table 4. The examined egg samples that comply with the permissible limits for the analyzed heavy metals

Metal	PL. (ppm)	Total egg samples within the permissible limits							
		Brown eggs		White eggs		Baladi eggs		Duck eggs	
		Nr	%	Nr	%	Nr	%	Nr	%
Copper	10[a]	20	100	20	100	20	100	20	100
Iron	c	-	-	-	-	-	-	-	-
Lead	0.5[a]	19	95	20	100	13	65	17	85
Cadmium	0.05[a]	20	100	20	100	20	100	20	100
Arsenic	0.002[b]	20	100	20	100	20	100	20	100

a Zmudzki and Szkoda (1996)
b Roychowdhury *et al.* (2003)
c No PL recorded for Fe in egg.

concentration levels in brown shell hen eggs may be due to high content of iron in the hens' diets. Iron is often added as a supplement in rations to enhance the shell color in brown eggs (Park *et al*., 2004), which increases their marketability. In the case of home-produced eggs, such as Baladi hen eggs and duck eggs, the birds are mainly fed on the domestic food remnants. In addition, fish, which are normally rich in iron are often fed to ducks. Chowdhury *et al*. (2011) found that Fe concentration levels in commercially produced hen eggs, home produced hen eggs and duck eggs were 29.23, 124.58, and 44.10 mg/kg, respectively. While values reported by Surtipanti *et al.* (1995) were 8.82 mg/kg and by Thomson *et al.* (2008) were 9.3 mg/kg in boiled table eggs.

Iron is an essential dietary element for humans and animals as it is an essential component of hemoglobin. Iron facilitates the oxidation of carbohydrates, proteins, and fats to control body weight. Low iron concentration level increases suitability to gastrointestinal infections, nose bleeding, and myocardial infarctions (Hunt, 1994). Iron occurs as a natural constituent of all foods of plant and animal origin and may also be present in drinking water. The effects of toxic doses of iron in animals include depression, coma, convulsions, respiratory failure, and cardiac arrest. Post-mortem examination

Table 5. Comparison of Acceptable Daily Intake (ADI) value of heavy metals with the calculated daily intake from eggs

Metal	ADI mg[a] /70 kg person	Mean of metals in total examined egg samples (ppm)	Calculated average daily intake of metals from consuming of 100g/egg/day[b]	
			mg/d/person	%
Copper	35.0	3.25	0.325	0.93
Iron	56.0	26.52	2.652	4.74
Lead	0.5	0.204	0.020	4.08
cadmium	0.07	ND	-	-
Arsenic	0.147	ND	-	-

[a]according to FAO/WHO (Codex, 2011). [b]Daily consumption for adult person according to Nutritional Institute, Egypt (1996 and 2006).

of intoxicated animals revealed adverse effects on the gastrointestinal tract. Iron from most animal sources, such as eggs, contain heme iron and is usually more readily absorbed than iron from plant sources, which contain non-heme iron (USDA, 2011).

Daily intake of copper and iron

The average daily intakes of copper and iron from consumption of 100 g of eggs are 0.325 and 2.652 mg/day/person respectively. This intake represent about 0.93% and 4.74% of ADI recommended by FAO/WHO for copper and iron respectively (Codex, 2011). It raises the important of copper and iron concentration levels in eggs in the human diets especially children. The daily intake of copper (0.325 mg/day/adult) which revealed in table 5 was increased than the Recommended Dietary Allowance (RDA) needed for the adult person/day (0.09 mg), While for Fe was relatively lower (2.652 mg/day/person) in compared with RDA needed for men and postmenopausal women (8 mg), pre-menopausal women (18 mg) and pregnant women (27 mg). Consumers should use the RDA as a guide to achieve adequate nutrient intake to help reduce the risk of chronic diseases (IOM, 2001). The findings indicate that the concentration levels of copper and iron in eggs in the mansoura city, Egypt marketes are safe for human consumption.

Lead residues

Lead is one of the toxic heavy metals that has a commutative toxic effect in humans and animals. The mean lead concentration levels in brown shell hen eggs, Baladi hen eggs, and ducks eggs were 0.185, 0.290, and 0.137 ppm respectively. The Lead concentration levels in white shell hen eggs could not be determined. The permissible limit (PL) of lead is 0.5 ppm according to Zmudzki and Szkoda (1996). In this study, 19/20 (95%) brown eggs, 20/20 (100%)

white eggs, 13/20(65%) Baladi eggs, and 17/20 (85%) duck eggs were comply the PL. (Table 4)

Table 5 shows that the average concentration levels of lead in all the examined table egg samples was 0.204 ppm which gives daily intake of about 0.020 mg/day/ person from consumption of 100 g eggs. This daily intake is 9.08% of ADI recommended by FAO/WHO (Codex, 2011). The findings raise the important of lead concentration levels in eggs, only 65 and 85% Baladi and Duck eggs comply lead permissible limits. Lead has been shown to be associated with impaired neurobehavioral functioning in children. Impaired neurobehavioral development was considered to be the most critical effect (IPCS, 1995). Inorganic lead compounds are classified by The International Agency for Research on Cancer (IARC) as a probably carcinogenic to humans (Codex, 2011).

Cadmium and Arsenic residues

Cadmium and Arsenic could not detected in all examined eggs samples which comply with the permissible limits and didn't contribute any percent in the ADI recommended by FAO/WHO (Codex, 2011). Recent study done on eggs by Waegeneers *et al.*, (2009) could not detect Cd and As in the majority of samples.

In conclusion, table eggs (Brown shell, white shell, Baladi hens' egg and ducks eggs) produced commercially or at homes are safe for human consumption from trace elements point of view. Two large eggs (100 g) consumed/ day covered the recommended Daily Allowance "RDA" needed for the adult person /day for Cu. All eggs sample comply the permissible limits of trce elements under studying except the Pb. Specific attention should be done for Baladi hen eggs as it contains the highest concentration levels of Pb that may affect human health., Feeds supplement added to hens diet should be measured and calculated its residues in eggs to avoid undesirable increase in their amounts. Copper sulphate pentahydrate shouldn't be added to surface water in the places where ducks swim and drink.

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