# Determination of Some Heavy Metals in Table Hen's Eggs

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**Abstract:** The aim of this study was to determine the content of copper, zinc, lead, cadmium and arsenic in table hen's egg samples (commercial, home produced and organic, 40 for each), in Egypt. Atomic absorption spectrophotometer was used for analysis of metals. The mean of heavy metals levels (ppm fresh weight) for commercial, home produced and organic egg samples were 0.644 ± 0.02, 0.62 ± 0.03 and 0.436 ± 0.04 Cu; 53.35 ± 1.06, 60.56 ± 1.14 and 49.76 ± 0.6 Zn; 0.23 ± 0.08, 0.057 ± 0.02 and 0.096 ± 0.04 Pb respectively, while Cd and As could not be detected from any of the examined samples. The average daily intake (mg/kg/person) due to consumption of 100g eggs/day were calculated as 0.058 Cu, 5.52 Zn and 0.013 Pb while ADI (mg/70kg person/day) are 35,70 and 0.5 for the same metals respectively. It was concluded that eggs are poor source of Cu and Zn, but home produced and organic eggs (20% each) are less contaminated by lead than commercial eggs (40%). All the examined (100%) hen's eggs samples were within permissible limit (PL) for Cu, Cd and As but 85% of commercial, 100% of home produced and 90% of organic egg samples were within PL of Pb while all samples (100%) were higher than PL of Zn. It was concluded that indoor feeding of home reared hen in Egypt lower level of heavy metal contamination in eggs.
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**Key words**: Heavy metals, table hen's eggs, spectrophotometer.

## 1. Introduction

Fresh eggs are among the most important and nutritious food in the daily diet. Moreover, eggs are included in several food products for various functions **(Sharkawy and Ahmed, 2002 and Leggli *et al*., 2010).** Global environmental pollution with heavy metal lead to an increased interest in metal contamination of food-stuffs and amongst them eggs which represent an important part of human's diet especially children **(IDF, 1991).** Despite substantial interest in the trace element content of eggs by poultry breeders, nutritionists and environmental scientists, available data about trace elements levels in eggs are scarce **(Nisianakis *et al*., 2009).**

Metallic elements are found in all living organisms where they play a variety of roles, as structural, components of control mechanisms (e.g. in nerves and muscles) and enzyme activator. Some metals are essential as copper (Cu), zinc (Zn), calcium (Ca), iron (Fe) and magnesium (Mg) those play a definitive role in the intrinsic mechanisms regulating vital biological processes **(Shang and Hong, 1997).** Whereas others are non essential metals and even toxic in trace amounts, especially lead (Pb), cadmium (Cd), mercury (Hg) and arsenic (As) **(Chen *et al*, 1999; Järup, 2003; Cheng and Dong, 2005 and Dundar and Deryaoglu, 2005).**

Essential elements deficiency results in impairment of biological function, but when their intakes exceed the recommended quantities significantly have harmful effect and even may be toxic **(Fuh *et al*., 2003; Huang, 2003; Ashraf, 2005 and Narin *et al*., 2005).** Copper is an essential trace element, normal constituent of animal tissues and fluids, crucial in hemoglobin synthesis and other enzymes functions. Both deficiency and excess of Cu in the mammalian system result in untoward effects **(Hostynek *et al*., 1993).** Toxic level of Cu may lead to Wilson's disease (excessive accumulation of Cu in liver, brain, kidney and cornea) and Menke's disease (peculiar hair, severe mental retardation, neurological impairment and death before 3 years of age) **(Goyer, 1996).**

Zinc is one of the most abundant nutritionally essential elements in the human body. It is essential to the structure and function of large number of macromolecules and for over 300 enzymatic reactions **(Tapiero and Tew, 2003).** Zinc plays a role in immune function, protein synthesis, wound healing, DNA synthesis and cell division; consequentially it supports normal growth and development during pregnancy, childhood and adolescence **(Prasad, 1995, Heyneman, 1996 and Solomons, 1998).** Dietary Zn deficiency was reported among the poor of the Middle East in children and adolescents from widely diverse areas including Egypt. Major manifestations include growth retardation, pregnancy complications, suppressed immunity, poor healing, dermatitis and impairment in neuropsychological functions

**(Sandstead, 1991).** Also hair loss, diarrhea, delayed sexual maturation and eye and skin lesions in more severe cases **(Prasad, 2004 and Maret and Sandstead, 2006).**

Lead found everywhere in the environment and at low levels in almost all living organisms **(Doganoc, 1996).** The general population is exposed to Pb from air and food. During the last century, Pb emissions from petrol to ambient air caused considerable pollution **(Järup, 2003)**. Lead ingested by chicken is deposited in bones, soft tissues and eggs, so contaminated egg yolk represents a potential public health hazard especially to children repeatedly consuming eggs **(Trampel *et al*., 2003),** moreover children have high gastrointestinal uptake and permeable blood-brain barrier **(Järup, 2003).** As Pb can be passed from hen to the egg, repeated consumption of contaminated eggs from a family owned flocks provide continuing dietary source of Pb **(Hui, 2002 and Trampel *et al*., 2003).** Lead is a neurotoxicant and of major public health concern which causes both acute and chronic intoxication **(Gossel and Bricker, 1990),** moreover it causes encephalopathy in children **(Carl, 1991).**

Cadmium is a toxic metal that has number of industrial applications as metal plating, pigments, rechargeable batteries and plastics. However, food is the primary source of Cd exposure **(WHO, 1992),** and its adverse health effects occur in the form of kidney damage but possibly also bone effects and fractures **(Järup, 2003).**

Exposure to arsenic is mainly via food intake and drinking water. Long term exposure to As is related to risk of various forms of cancer (mainly skin cancer) and numerous non cancer diseases including skin lesions, diabetes, chronic cough and toxic effect on liver, kidney, cardiovascular system and peripheral and central nervous systems **(Järup, 2003 and Vahter, 2007).**

There is a perception among private chicken owners that home produced eggs are healthier than the commercially produced ones because hens live in a chicken-friendly environment and because one does not suspect the private garden to be contaminated **(Waegeneers *et al*., 2009a).** Whereas, studies have shown that chickens foraging on soils contaminated with environmental pollutants accumulate these compounds into their eggs, thereby home-produced eggs shown higher contamination levels than commercially produced eggs **(Waegeneers *et al*., 2009b).** Consequently the demand for organic food product has increased during the last decades due to their probable health effects **(Soltoft *et al*., 2011).**

The mineral composition of hen's eggs is increasingly required for different purposes as estimation of accumulation of toxic elements from hen's eggs and the role of egg composition in human nutrition. However, the accurate determination of trace metals in hen's eggs is still an analytical challenge, due to their low concentration level and difficulties that arise from matrix characteristics. Flame atomic absorption spectrometry (FAAS) is a powerful detection technique for determining trace elements **(Leggli *et al*., 2010).**Therefore, this study was conducted to determine some heavy metal contents (copper, zinc, lead, cadmium and arsenic) in table hen's eggs from three sources (commercially produced, home produced and organic eggs) and compare the level of these metallic elements in eggs for human consumption with maximum permissible limit (PL).

## 2. Materials and Methods

**Collection of samples:**

One hundred and twenty random table hen's egg samples (commercially produced, home produced and organic eggs, 40 each) were collected from different shops, homes and supermarkets. Samples were transferred in plastic bags to the laboratory where kept cold until the contents were removed.

**Preparation:**

Each egg were cut in the air cell end using pointed forceps and dissecting scissors that cleaned with soap and rinsed with distilled water for each egg. The content of each sample were placed in a chemically clean glass jar and weighed then blended. Samples were dried at 75°C until constant weight was obtained.

Digestion: (according to Abdel Kader, 1994 and Zaki, 1998)

One gram of dried samples was digested with mixture of sulphuric and nitric acids. The digestion process was continued until the solution became clear, then samples were transferred into volumetric flask and completed up to 25ml with distilled water. All samples were analyzed using Air-acetylene unit in Atomic absorption spectrophotometer GBC (Avanta) at central laboratory of Kafrelsheikh University for determination of copper, zinc, lead, cadmium and arsenic.

The accuracy of the method was confirmed by analysis of standard reference material calibration against standard solutions (Mono-element CPA chem., Bulgaria) for all elements and calibration graphs were linear in the ranges of 5-150 ppm for As, 1-5 ppm for Pb and Cu and 0.5-1.5 ppm for Zn and Cd. Blank absorbance values were monitored throughout the experiment and were subtracted from the readings before the results were calculated.

**Statistical analysis:**

Comparisons among data groups for each element were performed using ANOVA test according to Clarke and Kempson, 1997.

## 3. Results and Discussion

Statistical analytical results shown in table 1 reveal that, mean levels of copper content of commercial, home produced and organic table hen's egg samples are 0.644 ± 0.02, 0.62 ± 0.03 and 0.436 ± 0.04ppm fresh weights, respectively. Van Overmeire *et al*., 2006 recorded 0.60 and 0.51mg/kg average Cu content for eggs obtained from private owners and commercial free range chickens in Belgium. These results didn't differ greatly from levels determined in eggs from other countries by another investigators as 0.43 mg/kg in autumn and 0.52 mg/kg in spring, in home produced eggs in Belgium by Waegeneers *et al*, 2009a; 0.59 mg/kg in fresh eggs by Leblanc *et al*., 2005; 0.78 mg/kg in Nigeria by Fakayode and Olu-Owolabi, 2003 and 0.62mg/kg in British eggs by Ysart *et al*., 2000.

Copper content in the examined organic table hen's egg samples differ significantly from commercial and home produced egg samples but there is no significant difference between commercial and home produced egg samples (Table 1). Table 3 shows that all (100%) the examined table hen's egg samples had Cu concentration below the permissible limit (10ppm) according to Zmudzki and Szkoda (1996). Copper is essential element for several enzymes in the body of the bird (Goyer, 1996) as well as most Cu is stored in liver, bone and bone marrow where it is bound to metallothionine (Sarkar *et al*., 1983), that is explain the presence of low level of cu in eggs.

Results recorded in table 1 reveal that mean values of zinc in commercial, home produced and organic table hen's egg samples examined are 53.35 ± 1.06, 60.56 ± 1.14 and 49.76 ± 0.6 ppm fresh weights, respectively. Lower concentrations (mg/kg) of Zn in eggs were reported by other researchers, 20.3 in autumn and 19.2 in spring (Waegeneers *et al*., 2009a); 11.5 in private owners eggs and 9.7 in commercial farm chicken eggs (Van Overmeire *et al*., 2006); 10 (Leblance *et al*., 2005); 13.75 (Fakayode and Olu-Owolabi, 2003) and 13 (Ysart *et al*., 2000).

Zinc content in the examined table hen's egg samples differ significantly from commercial and home produced egg samples also there is significant difference between commercial and home produced egg samples (Table 1).

All the examined table hen's egg samples recorded Zn content higher than the PL (20ppm) according to Polish limit cited in Zmudzki and Szkoda, 1996 (Table 3).

Table 4 shows that the average daily intakes of Cu and Zn from consumption of 100g eggs are 0.058 and 5.52 mg/day/person which represent about 0.17 and 7.89% of ADI recommended by FAO/WHO. As the daily intake of Cu and Zn are relatively low, consequently eggs considered poor sources of Cu and Zn and that was previously reported by Jeng and Yang (1995) and Amer *et al*. (2006).

Regarding lead, the concentration range (with mean ± S.E) for commercial, home produced and organic table hen's egg samples are from N.D to 2.24 (0.23 ± 0.08), N.D to 0.441 (0.057 ± 0.02) and from N.D to 0.652 (0.096 ± 0.04) ppm fresh weights, respectively (Table 2). Lead content in the examined table hen's egg samples differ significantly from commercial and home produced egg samples also there is significant difference between commercial and home produced egg samples (Table 2).

According to lead PL (0.5 ppm) cited by Zmudzki and Szkoda (1996), 34 (85%), 40 (100%) and 36 (90%) of the examined commercial, home produced and organic table hen's egg samples are within the PL (Table 3). Table 4 declares that average concentration of Pb in all the examined table hen's egg samples are 0.131ppm that gives daily intake of about 0.013mg/day/person from consumption of 100g eggs that contributed about 2.6% of ADI recommended by FAO/WHO.

On the other hand cadmium and arsenic can not be detected from any of the examined table hen's egg samples (Table 2). Also Waegeneers *et al*., 2009a mentioned that Cd and As concentrations were below the limit of quantification for the majority of samples. Fakayoda and Olu-Owolabi (2003) recorded that average concentration of Cd in eggs was 0.07mg/kg which was comparatively greater than levels found in other countries. But Van Overmeire *et al*., 2006 reported average Cd level of 0.53 and 0.27 mg/kg in private owners and commercial farms eggs. Table 3 shows that PL of Cd according to Zmudzki and Szkoda (1996) is 0.05ppm and all (100%) of the examined table hen's egg samples are within the PL.

Our current study shows that organic eggs samples have significant difference to commercial and home produced egg samples and both organic and home produced egg samples are less contaminated with lead. These results differ from that obtained by previous investigators who reported that private owner's and home produced eggs had higher contamination levels than commercial produced eggs (Van Overmeire *et al*., 2006 and Waegeneers, *et al*., 2009b), this may be due to different management systems as the authors reported that chickens foraging on soils contaminated with environmental pollutant but in our country (Egypt), home produced eggs are mostly reared at home with indoor feeding.

**Table (1) Mean levels of copper and zinc in the examined table hen's egg samples.**

| Group | Eggs samples | No. of examined samples | Copper (ppm) | | | | Zinc (ppm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. +ve | Min. | Max. | Mean ± S.E | No. +ve | Min. | Max. | Mean ± S.E |
| I | Commercial | 40 | 40 | 0.415 | 0.807 | 0.644±0.02 A | 40 | 43.21 | 66.66 | 53.35±1.06 A |
| II | Home produced | 40 | 40 | 0.189 | 0.939 | 0.62±0.03 B | 40 | 49.53 | 74.38 | 60.56±1.14 aB |
| III | Organic | 40 | 40 | 0.044 | 0.652 | 0.436±0.04 ab | 40 | 44.13 | 55.27 | 49.76±0.6 ab |
| Total | | 120 | 120 | 0.044 | 0.939 | 0.583±0.02 | 120 | 43.21 | 74.38 | 55.16±0.72 |

No. +ve : number of positive samples

a, b represent significant difference to A,B respectively at P≤0.05

**Table (2) Mean levels of lead, cadmium and arsenic in the examined table hen's egg samples.**

| Group | Eggs samples | No. of examined samples | Lead (ppm) | | | | Cadmium (ppm) | Arsenic (ppm) |
|---|---|---|---|---|---|---|---|---|
| | | | No. +ve | Min. | Max. | Mean ± S.E | | |
| I | Commercial | 40 | 16 (40%) | N.D | 2.24 | 0.23±0.08 A | N.D | N.D |
| II | Home produced | 40 | 8 (20%) | N.D | 0.441 | 0.057±0.02 aB | N.D | N.D |
| III | Organic | 40 | 8 (20%) | N.D | 0.652 | 0.096±0.04 ab | N.D | N.D |
| Total | | 120 | 32 (26.7%) | N.D | 2.24 | 0.131±0.04 | N.D | N.D |

No. +ve: number of positive samples N.D: not detected

a, b represent significant difference to A,B respectively at P≤0.05

**Table (3): The examined table hen's egg samples that comply with the permissible limits for the analyzed heavy metals**

| Metal | Permissible limit (ppm) | Table hen's egg sample within permissible limit (PL) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Commercial | | Home produced | | Organic | | Total | |
| | | No. | % | No. | % | No. | % | No. | % |
| Copper | 10 [a] | 40 | 100 | 40 | 100 | 40 | 100 | 120 | 100 |
| Zinc | 20 [a] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lead | 0.5 [a] | 34 | 85 | 40 | 100 | 36 | 90 | 111 | 91.7 |
| Cadmium | 0.05 [a] | 40 | 100 | 40 | 100 | 40 | 100 | 120 | 100 |
| Arsenic | 0.002 [b] | 40 | 100 | 40 | 100 | 40 | 100 | 120 | 100 |

a : Zmudzki and Szkoda (1996) b: Roychowdhury et al. (2003)

**Table (4): Comparison of acceptable daily intake (ADI) value of heavy metals with the calculated daily intake from eggs.**

| Metal | ADI mg/70kg person [a] | Mean of metals in total examined egg samples (ppm) | Calculated average daily intake of metals from consumption of 100g egg/day [b] | |
|---|---|---|---|---|
| | | | mg/day/person | % [c] |
| Copper | 35.0 | 0.583 | 0.058 | 0.17 |
| Zinc | 70.0 | 55.16 | 5.52 | 7.89 |
| Lead | 0.5 | 0.131 | 0.013 | 2.6 |
| Cadmium | 0.07 | N.D | - | - |
| Arsenic [d] | 0.147 | N.D | - | - |

a: FAO/WHO, Joint Expert committee on food Additives WHO Technical Report series, 1972, 1974c, 1982, 1987 and 1989.

b: Daily consumption of milk for adult person according to Nutrition Institute, Cairo, A.R.E.

c: Percentage calculated to ADI d: Roychowdhury et al., 2003.

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