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DETERMINATION OF LEAD, CADMIUM, MERCURY AND COPPER CONCENTRATIONS IN HEN'S EGGS AT ASSIUT GOVERNORATE

(With 3 Tables)

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قياس مستويات الرصاص والكادميوم والزئبق والنحاس في بيض الدواجن في محافظة أسيوط

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في هذه الدراسه تم استخدام ١٢٥ عينه من بيض الدواجن (مائه منها تم جمعها من ٤ مزارع مختلفه بمحافظة أسيوط بواقع ٢٥ بيضه من كل مزرعه و ٢٥ بيضه من منازل الفلاحين بمحافظة أسيوط) وذلك لقياس مستويات الرصاص والكادميوم والزئبق والنحاس في البياض والصفار ومكونات البيضة كاملـــة. وقد دلت النتائـــج على ما يلى: (١) الرصاص (جزء في المليون) كان متوســـط تركيزه ١٤٣و٠ ، ٠٨٧و٠ ، ٠٤٢و٠ ، ٠٣٠و٠ في بياض بيض المزارع ١،٢،٣،٤ بينما كان ٢٧٩و٠ في بياض البيض البلدي. وعلي الجانب الآخر فقد كان تركيزه ٤٢٦و٠ ، ٢٥٥و٠ ، ١٧٠و٠ ، ١٤٦و٠ في صفار بيض المزارع ١،٢،٣،٤ بينما وصل تركيزه في صفار البيض البلدي ٨٥٠و٠. وقد أتضح جلياً من هذه النتائج الزيادة المعنوية لتركيز الرصاص في بياض وصفار البيض البلدي عن تلك التي وُجدت بالمزارع الأربعة كما كانت هناك زيادة معنوية في تركيز الرصاص في صفار البيض عنه في بياض البيض في كلٍ من المزارع الأربعة والبيض البلدي. وفي حالة البيضة كاملة فكان تركيز الرصاص ١٤٤و٠ كمتوسط بالنسبة للمزارع الأربعة ثم ٥٠٧و٠ للبيض البلدي. (٢) الكادميوم (جزء في المليون) كـــان تركيـــزه ٣٦٠و٠ ، ٣٠١و٠ ، ١٧٧و٠ ، ٠٩٤و٠ في بياض المزارع الأربعة بينما كان تركيزه ٧١٢و٠ في بياض البيض البلدي. ثم ٣٩٢و٠ ، ٢٧٧و٠ ، ١٥٩و٠، ١٠٧و٠ في صفار بيـــض المزارع الأربعة و ٩٠٥و٠ في صفار البيض البلدي. وفي حالة البيضة كاملة كان ٢٣٣و٠ في بيض المزارع الأربعة و ٧٨٩و٠ في البيض البلدي. كما لُوحظ وجود زيادة معنوية في تركيزه في الصفار عنه في البياض في جميع عينات البيض التي تم فحصها. (٣) الزئبق (جزء في المليون)

كان تركيزه ٩٠و٠ ، ٧٥٠و٠ ، ٤٥٠و٠ ، ٦٠٠و٠ في بياض المزارع الأربعة علي التوالي بينما كان ١٨٣و٠ في بياض البيض البلدي. وقد أوضحت النتائج وجود زيادة معنوية في تركيز الزئبق في بياض البيض البلدي عن نظيرها في بياض بيض المزارع التي تم فحصها. ولقد كان تركيز الزئبق في البيضة كاملة في المزارع الأربعة ٠٥٣و٠ (متوسط القيم) بينما كان ١٤٩و٠ في البيض البلدي. (٤) النحاس (جزء في المليون) تدرج تركيزه من ٨٤٢و٠ إلي ١٥٩و١ في بياض المزارع الأربعة ومن ٨٧٩و٠ إلي ٩٧٥و٠ في بياض البيض البلدي بينما تدرج من ٣٩٤و١ إلي ٨٦٢و١ في صفار بيض المزارع الأربعة ومن ٣٨٩و١ إلــي ٥١٠و١ في صفــار البيض البلدي. وفي حالة البيضة كاملة كان تركيزه ٢٥٠و١ في بيض المزارع و ١٣٣و١ في البيض البلدي. وقد أوضحت النتائج وجود فرق معنوي في تركيز النحاس في كل من البياض والصفار في بيض المزارع الأربعة التي تم فحصها ولكن لم يوجد أي فرق بين تركيزه في بيض المزارع الأربعة والبيض البلدي. من هذه الدراسة تبين أن هناك زيادة معنوية في مستويات كل من الرصاص والكادميوم والزئبق في جميع العينات التي تم فحصها وخاصة البيض البلدي. لذلك يجب أخذ الإحتياطات اللازمة لما قد يسببه إستهلاك هذا البيض من خطورة علي صحة الإنسان.

SUMMARY

A total of 125 random egg samples were collected from four poultry farms (25 eggs/each farm), and 25 eggs from farmer's houses in Assiut governorate. The samples were examined for determination of lead, cadmium, mercury and copper contents. Our results revealed that: **lead** levels (ppm) in albumen were 0.143, 0.087, 0.042 and 0.03 in farms 1,2,3,4 while in balady eggs was 0.279. Also its level in the farms 1, 2 was significantly higher than farms 3, 4. On the other hand, Pb levels (ppm) in yolk were 0.426, 0.255, 0.170 and 0.146 in farms 1, 2, 3 and 4, respectively, while reached to 0.850 in balady eggs. The results clearified that Pb content in albumen and yolk of balady eggs was significantly higher than the mean content of Pb in albumen and yolk of all four farms. Pb concentration in egg yolks was higher than its concentration in egg albumen in all examined farms and balady eggs. In the whole egg, Pb concentration (ppm) was 0.144 as a mean for the four farms eggs and 0.507 for balady eggs. **Cadmium** concentration (ppm) in the albumen of the four farms were 0.36, 0.301, 0.177 and 0.094, while in balady eggs was 0.712. On the other hand, Cd levels (ppm) in yolk were 0.392, 0.277, 0.159 and 0.107 in the four farms respectively, but was 0.905 in balady eggs. For the whole egg, Cd concentration (ppm) was 0.233 in farms eggs (as a mean) and 0.789 in balady eggs. There was significant differences in Cd either in albumen or yolk among four farms and between the four farms and balady eggs. Also yolk was higher in its Cd content than albumen. **Mercury** concentration (ppm) in albumen was 0.09, 0.075, 0.045 and 0.060 in farm 1, 2, 3, 4, respectively, and 0.183 in balady eggs. Mercury is highly significantly increased in farms 1 and 2. On the other side, Hg content in albumen of balady eggs is significantly increased than that in the examined farms. The average concentration (ppm) of Hg in yolk was found to be ranged from 0.016 to 0.051 in the four farms but was 0.095 to 0.105 in yolk of balady eggs. From the statistical analysis, there is a significant differences in Hg levels in albumen, yolk and whole eggs among the four farms, and between the farms and balady eggs. The whole egg contained 0.053 ppm Hg in the farm's eggs and 0.149 ppm in balady eggs. **Copper** concentration (ppm) ranged from 0.842 to 1.159 and 0.879 to 0.975 in albumen of four farms and balady eggs respectively, while ranged from 1.394 to 1.862 and 1.389 to 1.510 in yolk of the four farms and balady eggs respectively. The whole egg from farms contained Cu (ppm) 1.250 and balady eggs contained 1.133 ppm Cu. In the present study, there was significant differences in copper concentrations in albumen and in yolk among the examined farms, but between the farms eggs and balady eggs there is no significant differences. The concentrations of Cu in yolks were significantly higher than in albumen in both farms and balady eggs. There is highly significant increase in Pb, Cd, and Hg in all examined samples but they were higher in balady eggs than that in farms eggs. Suggestive measures to protect human beings from excessive intake of lead, cadmium and mercury are given.

Key words: *Hens eggs- lead- cadmium- mercury- copper.*

INTRODUCTION

Eggs provide a unique, well balanced source of nutrients for all persons of all ages. Eggs and egg products are used in a wide variety of foods, including whole egg custard, mayonnaise, egg salad, egg nog and all types of bakery products. On the other hands eggs may constitute if contaminated a public health hazard. However, as the contamination of environment with heavy metals is becoming a problem, and as laying hens can sequester metals in their eggs (Burger and Gochfeld, 1991), the hygienic quality of eggs needs urgently to be monitored.

It is well known that diet has important role in the maintenance of health and the management of specific diseases in chickens, ducks, geese, turkey and rabbits. Commercially prepared pet foods may contain a wide spectrum of ingredients from many sources. These include animals, poultry, cereal, vegetables, and marine fish products and by-products, as well as added nutrients. Considering the very large number of constituents in pet foods, the possibility exists that may be contaminated by agricultural and industrial pollutants during final processing of the finished pet food products. In recent years the toxic effects of a number of non-essential metallic elements, especially lead, cadmium and mercury have claimed attention as they have a number of the essential elements as copper but at a higher concentrations than normals (Lucas, 1975).

Through the years considerable amounts of Pb have been mobilized into the environment. Industrial smelters, discarded batteries, burning of garbage and old paint wood are the main sources of environmental Pb. The Pb derived from petrol additives contributes not only to the intake through inhalation but also to the intake through ingestion as a result of fallout from vehicle exhaust on nearby food crops (WHO, 1972). Lead is recognized as a known neurotoxicant and of a major public health concern which causes both acute and chronic intoxication (Gossel and Bricker, 1990). It is known to cause encephalopathy in children (Carl, 1991). The provisional weekly intake of lead in food must not exceed than 0.05 ppm as recommended by FAO/WHO (1989). However, Carl (1991) postulated that the acceptable limits ranged from 0.05-0.2 ppm.

Cadmium, a toxic heavy metal, has a number of industrial applications, such as metal plating, pigments, batteries, and plastics. However, for most people the primary source of cadmium exposure is food (WHO, 1992), Since food materials tend to take up and retain cadmium. Cadmium is not known to have any beneficial effects, but can cause a broad spectrum of toxicological and biochemical dysfunctions (Theocharis *et al.*, 1994; Funakoshi *et al.*, 1995).

Mercury is considered as one of the most important pollutant in our environment. Mining, smelting, industrial discharge, mercury in paper pulp industries and fossil fuel. It is estimated that about 5000 tons of mercury per year may be emitted from burning coal, natural gas and from the refining of petroleum products, are considered as main sources of mercury in the environment (Goyer, 1996). Mercury is popular in agriculture as a results of its ability to counteract fungi and mold. It therefore has been widely used to prevent grain spoilage, as pesticides (fungicides for seed dressing) and in industry as wood preservative, production of dyes, initial explosive in boosters and igniters (Bartik and Piskac, 1981, Gossel and Bricker, 1990). During recent years the importance of mercury in the food-chain has become better understood. Inorganic and organic mercury derivatives are arising as effluents from industrial processes and converted in the lakes and rivers into Soluble methyl mercury. Toxic effects of Hg compounds in humans have been known for many years. The main effects of mercury on the kidney leading to uremia and anuria. The carly symptoms of a cute inorganic mercury poisoning are gastrointestinal ubset, abdominal pain, nausea, vomiting and bloody diarrhea (Shibamoto and Bjeldanes, 1993).

Copper is an essential trace element, a normal constituent of animal tissues and fluids, crucial in hemoglobin synthesis and other enzymes functions. Both deficiency and excess of copper in the mammalian system result in untoward effects (Hostynek *et al.*, 1993). As eggs are an unique and provide well balanced source of nutrients not only for the young but also for all ages. 20 mg/kg is the limit of copper recommended for adults by the Food Standard Committee 1965 (Watson, 1993). The aim of this study was to determine the concentrations of some heavy metals in eggs either from farms or from balady hens collected from Assiut Governorate.

MATERIALS and METHODS

MATERIALS:

The egg samples (125 eggs) were collected from four poultry farms (25 eggs/each farm), in Assiut Governorate, and 25 balady eggs (collected from farmers houses). Albumen and yolk were separated and homogenized with an electric mixer, and stored in clean bottles at -20 C until measuring of heavy metals. Albumen and yolk of each egg were weighed, then the average weights of albumen and yolk were calculated to determine the metals concentrations in the whole eggs.

METHODS:

1- Estimation of metals:

Five grams from albumen or yolk were digested by using a mixture of $HClO_4$-HNO_3. Mercury was determined by atomic absorption spectroscopic technique utilizing Ishimadzu atomic absorption/flame spectrophotometer Model AA-620. Lead, cadmium and copper were determined by using atomic absorption spectrophotometer (GBC 906 AA).

2- Statistical analysis:

Student's "t" test was used to calculate the significance between the metals concentrations in each farm eggs in albumen, yolk and whole egg and that in balady eggs, as well as between the mean metals concentrations in farms eggs and balady eggs. Probability values 0.05 and 0.001 were considered statistically significant and this according to Kalton (1967).

RESULTS

The obtained results in this study are summarized in Tables 1, 2 and 3.

DISCUSSION

Lead levels (ppm) in albumen, Table 1, were 0.143, 0.087, 0.042 and 0.03 in farms 1, 2, 3, 4 while in balady eggs was 0.279 which is higher than that in the four farms. Also the mean Pb level in the farms 1, 2 was significantly higher than farms 3, 4. On other hand, Pb levels (ppm) in yolk were 0.426, 0.255, 0.170 and 0.146 in farms 1, 2, 3 and 4, respectively, but significantly higher in balady eggs (0.850). It is also clear from the results that Pb content in albumen and yolk of balady eggs was significantly higher than the mean content of Pb in albumen and yolk of all examined four farms, Table 3.

The present results revealed that Pb concentration in egg yolks was higher than its concentration in egg albumen in all examined farms and balady eggs, Table 3. This is supported by Mazliah *et al.* (1989) who reported that Pb content of egg yolks from Pb-treated hens was significantly higher than that of control yolks and also was in agreement with the results of Tanaka *et al.* (1973) and Jeng and Yang (1995). The concentrations of Pb in albumen, yolk and whole egg of ducks were 13.6, 84.7 and 44.6 ng/g respectively (Jeng and Yang, 1995). Lead levels of common terns were correlated with laying hens and their eggs (Burger and Gochfeld, 1991).

In the present study, the average weights (grams) of albumen and yolk were 33.2 and 21.8 for farm eggs, 27.7 and 18.4 for balady eggs. Therefore, when converted to whole egg basis, Pb concentration (ppm) was 0.144 as a mean for the examined four farms eggs and 0.507 for balady eggs.

The differences of Pb concentrations in albumen and yolk between farms and balady eggs may be due to regional differences arising from dietary sources or contamination of the environment. Eggs laid by normal hens contained less than 0.040 and 0.080 to 0.180 ppm Pb in albumen and yolk respectively (Mazliah *et al.*, 1989). Lead concentrations in albumen and yolk of chicken eggs were both <50 ppb (Tanaka *et al.*, 1973). Eggs of common terns contained 0.089 ppm Pb (Burger and Gochfeld, 1991). Wang (1991) reported that albumen and yolk of chicken eggs contained 0.15 to 0.21 ppm Pb. Vodela *et al.* (1997) reported that Pb concentrations in yolk and albumen of eggs produced laid by normal broiler breeders were (ppm) 0.11 and 0.014 respectively.

The mean Cd concentration (ppm), Tables 1& 3, in the albumen of the examined four farms were 0.36, 0.301, 0.177 and 0.094 respectively, while in balady eggs it was 0.712. On the other hand, Cd levels (ppm) in yolk were 0.392, 0.277, 0.159 and 0.107 in the four farms but it was 0.905 in balady eggs. For the whole egg, mean Cd concentration (ppm) was 0.233 in farms eggs and 0.789 in balady eggs, Table 3. There is significant differences in Cd in albumen and in yolk among four farms and between the four farms and balady eggs. Also yolk was higher in its Cd content than albumen.

Leach *et al.* (1979) reported that egg powder from normal hens contained 0.05 ppm Cd, amounting to about 0.006 ppm Cd in fresh eggs. Burger and Gochfeld (1991) found that eggs of terns contained 0.004 ppm Cd, but the Cd levels in most eggs were below the detection limit (0.5 ng/g). The mean Cd concentrations in albumens, yolks and whole eggs of ducks were 1.8, 3.8 and 2.7 ng/g, respectively (Jeng and Yang, 1995). Vodela *et al.* (1997) reported that Cd concentrations in yolk and albumen of eggs produced laid by normal broiler breeders were (ppm) 0.63 and 0.666, respectively. Mumma *et al.* (1986) reported that cereals and grains contain from 0.01 to 0.6 ppm Cd this may the original source of Cd to these animals.

The mean concentration of Hg (ppm) Tables 2 & 3, in albumen was 0.09 in farm 1, 0.075 in farm 2, 0.045 in farm 3, 0.06 in farm 4 and 0.183 in balady eggs. Mercury is highly significantly increased in farms 1 and 2. On the other side, Hg content in albumen of balady eggs is significantly increased than that in the examined farms, Table 3. The average concentration (ppm) of Hg in yolk was found to be ranged from 0.016 to 0.051 in the four farms but was 0.099 in yolk of balady eggs. From the statistical analysis, there are a significant differences in Hg levels in albumen, yolk and whole eggs among the four farms, and between the farms and balady eggs, Tables 2 & 3.

The whole egg contained 0.053 ppm Hg in the farm's eggs and 0.149 ppm in balady eggs, Table 3. The normal content of Hg in eggs is 1-20 ppb (Bartik and Piskac, 1981). Our results in the present study revealed a higher Hg concentrations in the whole egg either in the farms eggs or in balady eggs and this is in disagreement with the results reported by Bartik and Piskac (1981).

It was found that eggs laid by hen fed 8% herring meal, contained 40 and 15 ppb of Hg in albumens and yolks, respectively (March *et al.*, 1974). Hens fed corn treated with alkyl mercury laid eggs were found containing 10.9 ppm Hg in their albumen and 4 ppm in yolks (Tejning and Vesterberg, 1964). Tanaka *et al.* (1973) reported that albumen and yolk of chicken eggs contained <10 to 80 ng/g and <10 to 20 ng/g Hg. Jeng and Yang (1995) found that the concentrations of Hg (ng/g) in albumen, yolks and whole eggs of ducks were 17.8, 9.7 and 14.3, respectively. An earlier study has already indicated that Hg was preferentially bound by ovalbumen of albumen (Magat and Sell, 1979).

The concentrations of Hg in albumen were significantly higher than in yolk and this is in agreement with the previous studies (Tejning and Vesterberg, 1964; Tanaka *et al.*, 1973; Magat and Sell, 1979; March *et al.*, 1974; Jeng and Yang, 1995)

The concentrations of copper (ppm), Tables 2 & 3, in albumen ranged from 0.842 to 1.159 in the examined four farms, and 0.925 in balady eggs, while in yolk ranged from 1.394 to 1.862 in farms eggs and 1.448 in balady eggs. The whole egg from farms contained copper (ppm) 1.250 and balady eggs contained 1.133 ppm Cu. In the present study, there were significant differences in copper concentrations in albumen and in yolk among the examined farms, but between the examined farms eggs and balady eggs there is no differences, Table 3.

Copper concentrations in eggs showed great variation in different studies. Fresh whole hen egg, raw yolk and raw albumen contained 1.0, 3.1 and 0.5 ppm Cu (Pennington and Calloway, 1973). Tanaka *et al.* (1973) found that Cu concentrations in albumen and yolk of hens eggs were 0.4 and 1.32 ppm. Leach *et al.* (1979) reported that hens eggs contained 0.55 ppm Cu. Copper level was 9.9 ppm in the yolk of hens eggs (Grau *et al.*, 1979). Scott *et al.* (1982) found that Cu concentration was 2.5 ppm in whole hens eggs. Jeng and Yang (1995) found that Cu concentrations were 0.83, 1.36 and 1.06 ppm in albumen, yolk and whole egg of ducks.

The total copper content of the average hen's egg is about 30 mg. Also in study of determining the Cu concentration in eggs from hens fed on good practical rations, it was found to be 31.4 mg (Dewar *et al.*, 1974). In the present study, Cu concentration was found about two-thirds in yolk and one-third in the albumen, Tables 2 & 3, and this result is in agreement with Hill (1974).

The concentrations of Cu in yolks were significantly higher than in albumen in both farms and balady eggs, Table 3. This is in agreement with the results obtained by Tanaka *et al.* (1973) and Jeng and Yang (1995).

Finally, the source of contaminated eggs by the toxic heavy metals like lead, cadmium and mercury may be attributed to the bad quality feed and water admitted to these hens either in the farms or balady hens.

One of the most important environmental issues today is ground water contamination. Water contamination with heavy metals has been reported (Schumacher *et al.*, 1990; Srikanth *et al.*, 1993). Heavy metals emitted by industries, traffic, municipal wastes and hazardous wastes sites have resulted in a steady rise in contamination of ground water (Yang *et al.*, 1989). Human and animal exposure due to occupational or environmental contamination is rarely limited to a single chemical or pollutant.

CONCLUSION

The food and water normally supplies a major amounts of total daily heavy metals intakes by animals and man. Small quantities of heavy metals are also normally contributed by the atmosphere except in areas near or adjacent to mines and factories where substantial atmospheric pollution can occur. With the rise of modern industrial technology and with the increasing urbanization and motorization of large sections of populations, these sources of heavy metals, together with contamination of the water supplies, may constitute an increasing significant source of these heavy metal with possible long-term dangers to human and animal health.

According to eating habits of hens (balady) as they eat cereals and grains, the elevation of Pb, Cd and Hg in investigated egg samples may return to either they come from feedstuffs, or drinking water, or air breathed by hens, or from all these sources.

Although both Pb and Cd are considered prior pollutants, Pb would appear to be a more widespread hazard with current exposure, being 10 - 100 times above the permissible limits. On the assumption that the animals bodies have limited tolerance toward increments in exposure to these toxic metals, a goal for preventive efforts would be that anthropogenic release should not add additional significant amount to the original background levels. Although variations seem to occur from place to place and from locality to locality and with dietary habits, natural exposure levels may provide a useful guide and good reference, in particular with regard to lead.

REFERENCES

Bartik, M. and Piskac, A. (1981): Copper. In: Vet. Toxicology, Elsevier Scientific Publishing Company, Amsterdam, Oxford, New York., pp. 84, 96-97.

Burger, J. and Gochfeld, M. (1991): Cadmium and lead in common terns (Aves: Sterna hirundo): Relationship between levels in parents and eggs. Environ. Assess., 16: 253-258.

Carl, M. (1991): Heavy metals and other trace elements. Monograph on residues and contaminants in milk and milk products. Chapter 6. Int. Dairy Federation Belgium.

Dewar, W.A.; Teague, P.W. and Downie, J.N. (1974): Br. Poultry Sci., 15: 119.

FAO/WHO (1989): Evaluation of certain food additives and contaminants. Who Technical Report Series No. 776, Geneva.

Funakoshi, T., Ohta, O.; Shimada, H. and Kojima, S. (1995): Effects of dithiocarbamates and cadmium on the enzymatic activities in liver, kidney, and blood of mice. Toxicol. Lett., 78: 183.

Gossel, T.A. and Bricker, J.D. (1990): Metals. In: Principles of Clinical Toxicology. 2nd Ed., Raven Press, New York, pp. 162-192.

Goyer, R.A. (1996): Toxic effects of metals. In: Casarett and Doull,s Toxicology. Amdur, M.O.; Doull, J. and Klassaan, C. D. (eds.).

The basic sciences of poisons. Pergamon Press. New York. pp. 691-736.

Grau, C.R.; Roudybush, T.E. and McGibbon, W.H. (1979): Mineral composition of yolk fractions and whole yolk from eggs of restricted ovulator hens. Poultry Sci., 58: 1143-1148.

Hill, R. (1974): Copper. In: Trace Elements Metabolism in Animals. Hoekstra, W.G. *et al.* (eds), Vol. 2, Univ. Park Press, Baltimore, Maryland, p. 632.

Hostynek, J.J.; Hinz, R.S.; Lorence, C.R.; Price, M. and Guy, R.H. (1993): Metals and the skin. Critical Reviews in Toxicology, 23 (2): 171 - 235.

Jeng, S.L. and Yang, C.P. (1995): Determination of lead, cadmium, mercury and copper concentrations in duck eggs in Taiwan. Poultry Science, 74: 187-193.

Kalton, G. (1967): Introduction to statistical ideas from soil scientists. 2 nd Ed. Academic Press. London.

Leach, R.M.; Wang, K.W. and Baker, D.E. (1979): Cadmium and the food chain: The effect of dietary cadmium on tissue composition in chicks and laying hens. J. Nutr., 109: 437-443.

Lucas, J. (1975): Industrial pollution by the mineral elements. In our polluted food. A survey of the risks. Charles Knight and Company limited. London and Tonbridge. pp. 157-199.

Magat, W. and Sell, J.L. (1979): Distribution of mercury and selenium in egg components and egg-white protein. Proc. Soc. Exp. Biol. Med., 161: 458-463.

March, B. E.; Soong, R.; Bilinski, E. and Jonas, R.E.E. (1974): Effects on chickens of chronic exposure to mercury at low levels through dietary fish meal. Poultry Sci., 53: 2175-2181.

Mazliah, J.; Barron, S.; Bental, E. and Reznik, I. (1989): The effect of chronic lead intoxication in mature chickens. Avian Dis., 33: 566-57.

Mumma, R.O.; Rashid, K.A.; Shane, B.S.; Scarlett-Kranz, J.M.; Hotchkiss, J.H.; Eckerlin, R.H.; Maylin, G.A.; Lee, C.Y.; Rutzke, M.; Gutenmann, W.H.; Bache, C.A. and Lisk, D.J. (1986): Toxic and protective constituents in pet foods. Am. J. Vet. Res., 47 (7): 1633 - 1637.

Pennington, J.T. and Calloway, D.H. (1973): Copper content of foods. J. Am. Diet. Assoc., 63: 143-153.

Schumacher, M.; Bosque, M. A.; Domingo, J. L. and Corbella, J. (1990): Lead and cadmium concentrations in marine organisms from the terragona coastal waters, Spain Bull. Environ. Contam. Toxicol., 44: 784-789.

Scott, M.L.; Nesheim, M.C. and Young, R.J. (1982): Nutrition of the chicken. 3 rd ed. Ithaca, NY.

Shibamoto, T. and Bjeldanes, L.F. (1993): Introduction to food toxicology. Academic Press Inc. Harcourt Brace and Company. New york. Food Sci. & Technol., Int. Series, 126-132.

Srikanth, M.; Madhumohan, A.R.; Shrvan, C.K. and Khanum, A. (1993): Lead, cadmium, nickel and zinc contamination of ground water around Hussain Sagar Lake, Hyderabad, India. Bull. Environ. Contam. Toxicol., 50: 138-143.

Tanaka, Y.; Ikebe, K.; Tanaka, R. and Kunita, N. (1973): Contents of heavy metals in food (1). J. Food Hyg. Soc. Jpn., 14(2): 196-201.

Tejning, S. and Vesterberg, R. (1964): Alkyl mercury-treated seed in food grain: Mercury in tissues and eggs from hens fed with grain containing methyl mercury dicyandiamide. Poultry Sci., 43: 6-11.

Theocharis, S.E.; Margelli, A.P.; Giannakou, N.; Drakopoulos, D.S. and Mykoniatis, M.G. (1994): Cd-induced hepatotoxicity in three different rat strains. Toxicol.Lett., 70: 39.

Vodela, J.k.; Lenz, S.D.; Renden, J.A.; Mcelhenney, W.H. and Kemppainen, B.W. (1997): Drinking water contaminants (Arsenic, cadmium, lead, benzene, and trichloroethylene). 2. Effects on reproductive performance, egg quality, and embryo toxicity in broiler breeders. Poultry Sci., 76: 1493-1500.

Wang, H. (1991): Determination of lead in egg white and egg yolk by Zeeman atomic absorption spectrometry. Atomic Spectroscopy, 12: 87-88.

Watson, D. (1993): Chemical contaminants. In: Safety of chemicals in food. 1 st Ed., Ellis Hoewood Limited. England.

WHO (1972): Evaluation of Hg, Pb, Cd and the food additives, amaranth, diethyl pyrocarborate and octyl galate. Report No. 4: 34 - 50.

WHO (1992): Cadmium. IPCS Environmental Health Criteria 134. WHO, Geneva.

Yang, R.S.H.; Goehl, T.J.; Brown, R.D.; Chatham, A.T.; Arneson, D.W.; Buchanan, R.C. and Harris, R.K. (1989): Toxicological studies of a chemical mixture of 25 ground water contaminants. 1: Chemistry development. Fund. Appl. Toxicol., 13: 366-376.

Table 1: Lead and cadmium concentrations in farms and balady eggs collected from Assiut governorate.

Source of eggs	The value	LEAD			CADMIUM		
		albumen	yolk	whole egg	albumen	yolk	whole egg
Farm 1	mean ± S.E.	0.143 ± 0.003	0.426 ± 0.007	0.255 ± 0.003	0.360 ± 0.013	0.392 ± 0.011	0.373 ± 0.009
	range	0.132-0.153	0.402-0.450	0.242-0.267	0.308-0.405	0.351-0.432	0.329-0.399
Farm 2	mean ± S.E.	0.087 ± 0.002a	0.255 ± 0.003a	0.153 ± 0.001a	0.301 ± 0.005a	0.277 ± 0.005a	0.291 ± 0.005a
	range	0.078-0.095	0.243-0.269	0.150-0.157	0.279-0.320	0.256-0.302	0.270-0.307
Farm 3	mean ± S.E.	0.042 ± 0.001ab	0.170 ± 0.002ab	0.093 ± 0.001ab	0.177 ± 0.003ab	0.159 ± 0.002ab	0.169 ± 0.002ab
	range	0.037-0.047	0.160-0.180	0.088-0.100	0.170-0.190	0.150-0.168	0.162-0.177
Farm 4	mean ± S.E.	0.030 ± 0.001abd	0.146 ± 0.002abd	0.076 ± 0.001abd	0.094 ± 0.001abd	0.107 ± 0.003abd	0.099 ± 0.001abd
	range	0.027-0.033	0.138-0.154	0.072-0.080	0.087-0.100	0.098-0.119	0.095-0.103
Balady eggs	mean ± S.E.	0.279 ± 0.014abde	0.850 ± 0.035abde	0.507 ± 0.020abde	0.712 ± 0.019abde	0.905 ± 0.017abde	0.789 ± 0.013abde
	range	0.0224-0.338	0.704-0.983	0.416-0.568	0.660-0.814	0.854-0.970	0.761-0.849

a: Significant difference from farm 1 eggs at $p < 0.001$.
b, c: Significant difference from farm 2 eggs at $p < 0.05$ and $p < 0.001$.
d: Significant difference from farm 3 eggs at $p < 0.001$.
e: Significant difference from farm 1 eggs at $p < 0.05$

Table 2: Mercury and copper concentration in farms and balady eggs collected from Assiut governorate.

Source of eggs	The value	MERCURY			COPPER		
		albumen	yolk	whole egg	albumen	yolk	whole egg
Farm 1	mean ± S.E.	0.090 ± 0.002	0.051 ± 0.001	0.074 ± 0.001	0.842 ± 0.013	1.394 ± 0.023	1.060 ± 0.017
	range	0.081-0.097	0.045-0.056	0.067-0.079	0.799-0.882	1.316-1.484	1.004-1.116
Farm 2	mean ± S.E.	0.075 ± 0.001a	0.040 ± 0.001a	0.058 ± 0.003a	0.934 ± 0.013a	1.557 ± 0.023a	1.181 ± 0.010a
	range	0.069-0.081	0.036-0.043	0.042-0.065	0.888-0.982	1.479-1.650	1.138-1.210
Farm 3	mean ± S.E.	0.045 ± 0.001ab	0.016 ± 0.001ab	0.033 ± 0.001ab	1.024 ± 0.009ab	1.785 ± 0.024ab	1.325 ± 0.011ab
	range	0.040-0.050	0.014-0.017	0.030-0.037	0.989-1.058	1.689-1.876	1.288-1.382
Farm 4	mean ± S.E.	0.060 ± 0.001abd	0.033 ± 0.001abd	0.049 ± 0.001acd	1.159 ± 0.006abd	1.862 ± 0.035ab	1.437 ± 0.015abd
	range	0.052-0.066	0.030-0.036	0.044-0.054	1.146-1.190	1.737-1.961	1.380-1.476
Balady eggs	mean ± S.E.	0.183 ± 0.002abde	0.099 ± 0.001abde	0.149 ± 0.001abde	0.925 ± 0.012ade	1.448 ± 0.018bde	1.133 ± 0.010acde
	range	0.174-0.195	0.095-0.105	0.145-0.157	0.879-0.975	1.389-1.510	1.103-1.170

a: Significant difference from farm 1 eggs at $p < 0.001$.
b, c: Significant difference from farm 2 eggs at $p < 0.05$ and $p < 0.001$.
d: Significant difference from farm 3 eggs at $p < 0.001$.
e: Significant difference from farm 1 eggs at $p < 0.05$.

Table 3: Heavy metals concentrations in farms and balady eggs (mean ± S.E.M.).

Source of eggs	LEAD			CADMIUM			MERCURY			COPPER		
	albumen	yolk	whole egg	albumen	yolk	whole egg	albumen	yolk	whole egg	albumen	yolk	whole egg
Farms eggs	0.075 ± 0.022	0.249 ± 0.058c	0.144 ± 0.035	0.233 ± 0.051	0.234 ± 0.055	0.233 ± 0.053	0.067 ± 0.008	0.035 ± 0.006c	0.053 ± 0.007	0.989 ± 0.058	1.649 ± 0.092d	1.250 ± 0.071
Balady eggs	0.279 ± 0.014a	0.850 ± 0.035bd	0.507 ± 0.020b	0.712 ± 0.019b	0.905 ± 0.017bd	0.789 ± 0.013b	0.183 ± 0.002b	0.099 ± 0.001bd	0.149 ± 0.001b	0.925 ± 0.012	1.448 ± 0.018d	1.133 ± 0.010

a,b: Significantly different from farms eggs at $p<0.05$ and $p<0.001$.

C,d. Significant difference between albumen and yolk in the same group at $p<0.05$ and $p<0.001$