Determination of Some Heavy Elements Residues in Some Organs of Migratory Quail in Relation to Public Health

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Abstract: ***The quantity of mineral nutrients in diet should be balanced to promote optimum response in humans' metabolism and the contamination with heavy metals must be monitored, in order to provide safety foodstuff for consumers. Organ meat is a good source of protein, and some organs, notably the liver and kidney, are rich in vital minerals. This study is focused on determination of ten heavy metals concentrations in the selected tissues and organs of migratory quails or common quail (European and East Asian populations of quail (Coturnix coturnix) which captured from different sites in the study area (North Western Coast, Egypt). The samples of liver, kidney and muscles (chest & leg) were analyzed for the presence of aluminum (Al), copper (Cu), iron (Fe), manganese (Mn), zinc (Zn) chromium (Cr), molybdenum (Mo), nickel (Ni), lead (pb) and strontium (Sr) by using Inductively Coupled Plasma Mass Spectroscopy (ICP-MS). The results showed that essential elements occur in high levels compared to the non-essential elements in the tissues of these migratory birds. Meanwhile, kidney is the tissue which has the highest level of most metals followed by liver and heart, the highest concentration of Cu was observed in liver samples. Also, liver was found to have gathered higher metal concentrations than muscle in the birds. The concentrations (mg/kg wet weight) of heavy elements in the selected studied organs are varied quietly such as, Al (48.61 - 395.9), Cu (2.84 - 6.64), Fe (162.3 - 882.7), Mn (2.18 - 12.2) and Zn (8.11- 25.5). The order of the levels of these trace elements obtained from the four different quail organs is Fe > Al > Zn > Mn > Cu. On the other hand the concentrations (mg/kg wet weight) were, Cr (2.45-14.51), Sr (1.97-8.65), Pb (1.06-6.17), Ni (0.84-5.42) and Mo (0.23-1.48). Also the order of the levels of these trace elements is Cr > Sr > Pb > Ni > Mo. The highest concentrations of aluminum, iron, manganese and zinc were detected in kidney samples followed by liver and heart samples, while the minimum values of the same elements were recorded in chest muscles. Moreover, correlations between metals concentrations were done and the results were compared to recommended limits for human consumption.***

Keywords: Trace elements, liver, Kidney, heart, muscles and Japanese quail.

1. Introduction

Common quail (*Coturnix coturnix*) breed throughout most of central and southern Europe, and in North Africa, including the Atlantic Islands close to Africa and Europe. August marks the start of the annual migration of millions of birds from their European breeding areas to their wintering grounds in Africa. Many will fly across the eastern Mediterranean towards Egypt, but the others reaches north China and north India, through Pakistan, Iran and Turkey [1]. Common quail is one of the most migratory birds which migrate from Europe to Egypt during autumn. During the hunting season, many thousands of these birds are caught in hunter nets on arrival to Mediterranean shore of Egypt. As other migratory birds, migratory quail act as possible (biological and/or mechanical) vectors playing an important role in the ecology [2]. Quail was selected as animal tool because a lot of interest has been shown by the farmers during the last few years in raising Japanese quail (*Coturnix coturnix japonica*). The information available concerning the nutritive requirements of the quail is somewhat limited as little work has been done on quails [3]. Free-living animals in natural ecosystems are specially exposed to various environmental factors. The environment is the main factor which determines health condition and population of wild game [4]. The majority of the published studies on sea birds were concerned on environmental pollution and the use of sea birds as a biomarker of diverse effects of chemical pollutants in marine environment. Generally, birds accumulated heavy metals in relation to their sources of pollution [5, 6]. Birds have always been a source of meat protein for human with a recent increasing trend in the consumption of poultry [7]. Meat is a valuable food source rich in many of the essential nutrients including protein (essential amino acids), minerals (e.g. iron, zinc and selenium), vitamins (e.g. vitamin E) and fat (essential fatty acids such as Omega 3 fatty acids). Beef, lamb, poultry and fish are considered the major sources of meat protein for humans [8]. Meat may also carry certain toxic substances, although the level of these toxic substances in muscle is generally low the offal such as liver and kidney showed higher concentrations of toxic substances than most other foods. Chemical residues in meat may present a hidden but they represent a serious threat to public health. Because residues generally cannot be seen, smelled or tasted, they are difficult to detect. The monitoring of raw meat for chemical residues is necessary to ascertain that approved compounds are not being misused and are not presenting a danger to consumers [9].

At present, many birds are domesticated and farmed commercially for food (e.g. turkey chicken) while others are still gathered annually from the wilderness for the same purpose (e.g. quail). As a result of their feeding habits, the meat of some birds is suspected to have additional nutritional benefits, but their populations are particularly susceptible to the effects of anthropogenic activities on the environment. Several biological and physiological processes, such as eating habits, growth, age, and breeding may influence metals concentrations and their distributions in birds [10]. From these metals, heavy metals (essential and toxic) which may be accumulate in the biological system and affect the birds in different ways. Generally, birds can be exposed to heavy metals both externally, by physical contact, and internally, by consumption of contaminated water, poultry feed, sewerage water, industrial effluents [11]. The concentration of heavy metals in internal tissues of poultry has been extensively determined by several researchers [12, 13, 14, 15, 16, 17, 18, 19, 11, 20, 21, 22]. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnification in the food chain. These pollutants often have direct physiological toxic effects because they are stored or incorporated in tissues, sometimes permanently [23]. Trace elements are divided into two categories, essential metals and toxic elements. Essential trace elements are copper (Cu), chromium (Cr), manganese (Mn), iron (Fe), cobalt (Co), zinc (Zn), molybdenum (Mo), nickel (Ni), magnesium (Mg) and selenium (Se). These are biologically essential nutrients and some species can regulate the body levels of them at constant levels, but the regulation is broken down at higher metal exposures and metal accumulation occurs [24, 25]. Trace elements such as arsenic (As), cadmium (Cd), lead (Pb), aluminum (Al), strontium (Sr) and mercury (Hg) are found in the environment throughout the world and have long been recognized as a serious concern. There are biologically nonessential with no known biological function and demonstrably toxic even at relatively low concentrations. They are potentially harmful to most organisms even relatively in low exposure level [26]. Heavy metals are most dangerous contaminants and the risk of their contamination in meat is of great concern for both food safety and human health because of the toxic nature of these metals at relatively minute concentrations [15]. Heavy metals taken in traces, bind with proteins and become nontoxic, but their high concentration, above the body tolerance level, results into severe pathological conditions. Their increased concentration reacts with important cellular components through, covalent and ionic bindings, resulting in damage to cell membrane and alteration of the normal cellular functions i.e. the enzymatic and the normal molecular systems of the cell. These metals alter the gene code by damaging the DNA structure [27].

Japanese quail (*Coturnix coturnix japanica*) is an interesting domestic economic species for commercial egg and meat production besides chicken. Quail is often used for investigation of physiological process in the birds, and is also a suitable experimental model for observation of relationship between essential elements and xenobiotics *in vivo* [28]. Food quality, safety and environmental contamination are primary public health concerns worldwide [29]. Consumption or exposure to high level of various heavy metals has many burdens on different organs of the body, for example high levels of Cu is known to cause damage to the liver; Zn has been found to produce adverse nutrient interactions with Cu. Others have found that Zn reduces immune function and the levels of high density lipoproteins. Iron may cause conjunctivitis, choroiditis and retinitis if it contacts and remains in the tissues. Cr long-term exposure can cause kidney and liver damage, and damage too circulatory and nerve tissue. In addition a metal like Cd can cause kidney dysfunctions and reproductive deficiencies and Pb may cause cognitive development problems, increase blood pressure and cardiovascular diseases; Hg can cause low intelligent quotient (IQ) and may affect the kidney. Generally health problems such as genetic mutation, deformation, miscarriages, cancer, kidney problems etc, have been attributed to pollution by heavy metals, these observations were recorded by many researchers who are interested in the analysis of the trace metal contents of the environmental samples and foods [14, 18, 30, 11, 21, 22]. Uncontrolled pollution levels particularly in developing countries have drawn more attention to the heavy metal problem. Regarding in Egypt, poultry meat as chicken and quail is a major source of proteins to the population and is widely consumed. On the other hand different concentrations of heavy metals were present in poultry edibles at the studied locations in Egypt. So exposure to heavy metals through poultry consumption may lead to health risks in Egypt, especially in areas with expanding industrial and agricultural activities [21]. There is however hardly information on the heavy metal content of organ meats (liver, kidneys, heart, and muscles) although they are sold and consumed as a valuable food source. Hence, little is known of the health risk associated with their consumption in Egypt. The risk of heavy metal contamination in organ meats is of great concern from both the food safety and public health perspective because of their toxicity at relatively minute concentrations. Because health safety is very important aspect of food quality, so the aim of this study was to examine the distribution of ten heavy metals concentrations in the selected tissues and organs (liver, kidney, heart, chest muscle and leg muscle) of migratory common quail and if these concentrations fell within the recommended tolerable levels for human consumption.

2. Materials and Methods

2.1 Materials

Two hundred random samples of liver, kidney, heart, chest muscle and leg muscle were included in this study; they were collected (40 of each) from forty apparently healthy live migratory common quail (*Coturnix coturnix*) birds that were captured and collected from different sites at North Western Coast, Egypt. After hunting these birds they slaughtered then the polyethylene bags containing the well identified samples were placed in ice box, and immediately transferred to a deep freezer at -20◦C till investigation. {Analysis was carried out using wet digestion method recommended by [31]}.

2.2 Methods

Digestion Procedure: This was done by weighing one gram of each sample and put in a conical flask. Twenty ml of digestion mixture (consisted of 1 part of conc. sulphuric acid 4 parts of perchloric acid and 10 parts of conc. nitric acid) were added to the tissue samples in all flasks and then the flasks were heated until the samples become clear and complete digestion. Flasks were left to cool at room temperature and diluted with de- ionized water to 50 ml in volumetric flasks. The digest were then filtered through Whattman filter papers. These samples were then used for analysis of heavy metals in ICP-MS for determination of Aluminum, Copper, Iron, Manganese, Zinc Chromium, Molybdenum, Nickel, Lead and Strontium levels in tissues of quail birds (liver, kidney, heart and muscles (chest and leg).

Preparation of blank: Blank solution consisting of 1 part of conc. sulphuric acid, 4 parts of perchloric acid and 10 parts of conc. nitric acid that was treated by the wet digestion procedure then diluted with de- ionized water to 50 ml in a volumetric flask. The blank was used to determine heavy metal contaminations that may be present in the chemicals used for wet digestion. The digest and the blank were analyzed in ICP-MS.

Calculation of heavy metals: Multi-element including Aluminum, Copper, Iron, Manganese, Zinc Chromium, Molybdenum, Nickel, Lead and Strontium concentrations were recorded directly from the digest scale of ICP and were calculated by the following equation according to [32].

Element in mg/kg = R x D/W

R= Reading of elemental concentration (mg/kg) from the digital scale of ICP, D = Dilution of prepared sample, W = Weight of the sample.

The concentration or the absorbency values of heavy metals in blank samples were also calculated and subtracted from each analyzed sample. The register values for heavy metals were expressed as mg/kg wet weight. Statistically data are presented as means ± standard deviations, according to Statistical Package for Social Science (SPSS) Ver. 14. Spearman correlation test was performed to investigate correlations between metals concentrations.

3. Results and Discussion

Summary statistics of trace element concentrations in selected tissues are presented in Tables (1 & 2) and Figures (1-10) respectively. Mean concentrations and standard deviations of aluminum, copper, iron, manganese and zinc in the liver, kidney, heart, chest muscle and leg muscle are recorded in Table (1) and figures (1-5) respectively. The concentrations (mg/kg wet weight) of heavy elements in the selected studied organs are varied quietly such as, Al (48.61 - 395.9), Cu (2.84 - 6.64), Fe (162.3 - 882.7), Mn (2.18 - 12.2) and Zn (8.11- 25.5). The order of the levels of the trace elements obtained from the four different quail organs is Fe > Al > Zn > Mn > Cu. The highest concentrations of aluminum, iron, manganese and zinc were detected in kidney samples, while the minimum values of the same elements were recorded in chest muscles (Table 1). Moreover, highest concentration of copper was detected in liver samples, while the minimum value was recorded in chest muscles. The results indicated that the levels of these heavy metals were a variable between the different organs and they possessed an unequal distribution of the metals throughout these organs. Aluminum is the third most abundant elements in the earth crust and biological system probably evolved in the presence of appreciable concentrations. Exposure is unavoidable because of the wide use of this element in day-to-day life and in industry [33]. The concentration of Al (mg/kg) in the examined tissue samples were 216.05 ± 211.7, 395.9 ± 31.92, 120.73 ± 75.44, 48.61 ± 25.21 and 55.73 ± 31.93 mg/kg in liver, kidney, heart, chest and leg muscle respectively. It can be clearly observed that kidney samples had the highest concentration of Al (395.9 mg/kg) and chest muscle had the lowest (48.61mg/kg). Excessive accumulation of heavy metals in food can result in serious systemic health problems in humans. Therefore, the FAO, WHO, EU, EOSQS and other regulatory bodies of various countries have established the maximum permitted concentrations of heavy metals in foodstuffs [19, 17, 18, 11, 21]. Al has been shown to have deleterious effects on the central nervous, skeletal, and hematopoietic systems of humans. The neurotoxicity of Al to patients with chronic renal disease is well established. Its presence in the bloodstream leads to accumulation in bone and brain causing an encephalopathy called dementia dialytica. It is worth mentioned that its accumulation in brain altered amino acid neurotransmitters, so it has been suggested to be an associated phenomenon in various neurological disorders as dementia, senile dementia, and Alzheimer disease [21]. Comparing our results with the previously reported metals data in poultry, it can be noticed that Al levels were higher than those reported by [14] who recorded 0.10–1.90 ug/g for aluminum in chicken samples and chicken product from Turkey; [34] who recorded that Al concentrations were 11.8, 6.1, 11.6 & 226 mg/kg in Greylag goose liver, kidney, muscle, and feather as aquatic bird of the Southwest Atlantic Coast of France and [35] who recorded that the maximum level of Al in the gizzard, lung, liver and pectoral muscle of quail was 106.8, 125.31, 104.9 & 76.98 mg/kg, respectively. In addition, our finding agrees with [36] who observed levels were ranged from 61.73 to 370 mg/kg for chicken shawarma in Egypt. Within the literature of specialty, we have not found any reference values of the concentration of Al in the tissues and organs taken from poultry. In addition the permissible Al dose for an adult is quite high (60 mg/ day) [37]. Also there is no information about maximum Al levels in poultry samples in Egyptian standards. Meanwhile, the concentrations of Al in different poultry parts in our study were below the WHO limit.

Regarding to copper, it should be highlighted that food is a principal source of copper as an essential micronutrient element for man and animal, required for normal biological activity for several enzymes. These enzymes are important in the structural integrity of collagen, detoxification of superoxide radicals, pigmentation, iron transport, and energy metabolism. Excess amount of copper in food may lead to copper toxicity [12]. In addition the present results revealed that levels of copper contents in quail organs was 6.64±4.35, 3.32±3.68, 4.69±9.22, 3.08±2.83 and 2.84±3.68 mg/kg in liver, kidney, heart, Chest muscle and leg muscle. Liver samples had the highest concentration of Cu (6.64 mg/kg) and leg muscle had the lowest (2.84 mg/kg) concentration. Although, copper is essential for good health but very high intakes can cause health problems such as liver and kidney damage, maximum copper concentration for meat and meat products has been proposed as 0.90–30 mg d^{-1} person [38]. Comparing our results with the previously reported metals data in poultry, it can be noticed that higher values were reported in Poland by [13] who observed that mean concentration of Cu in liver was higher (9.346 mg/kg) in comparison to mean value in muscle (4.822 mg/kg) of Japanese quails (*Coturnix coturnix japanica*). Taking into consideration, in Egypt levels detected by [36] were ranged from 0.01 to 9.4 mg/kg for chicken shawarma. Also according to [15] the Cu concentration ranged from 0.1 to 1.44 ug/g of in liver, kidney and meat of chicken from Borno State, Nigeria. With observation that, the highest copper concentration was found in the liver of chicken (1.44ug/g). It can be noticed that Cu levels were higher than those concentrations (1.22 to 4.71 mg/kg) in poultry liver samples from Romania and Belgium which recorded by [16]. But our results were lower than those concentrations (52.89, 8.09, 24.77 &8.6 mg/kg) in the gizzard, lung, liver and pectoral muscle of quail samples (*Coturnix coturnix japonica*) from Malaysia which recorded by [35]. On the other hand an earlier study by [11] reported that average concentrations of copper in liver of chicken samples were found to be 1.35, 1.861 and 2.254ppm from three selected areas from Pakistan, whereas these concentrations were 0.363, 0.357 and 0.447ppm in meat samples from the same locations. Although limited information is available on chronic copper toxicity, toxic levels of copper can lead to Wilson's and Menke's diseases [12]. The results of this study indicate that the high concentration of Cu was observed in liver samples and that may be due that, the liver is the first organ to encounter the ingested nutrients, drugs, and environmental toxicants that enter the hepatic portal vein from the digestive system [20]. According to [39] WHO permissible limit for copper in all foods is 40 mg/kg. Also maximum limit intake was set from 1 to 10 mg day^{-1} [37]. With consideration allowable dose of copper, the consumption of liver, kidney, heart, pectoral muscle and leg muscle of quail bird are were below the permissible limit and safe in Cu consumption.

Concerning iron, it is an important mineral for life and needed to help the red blood cells deliver oxygen to the rest of the body. Numerous foods are sources of iron and the good sources of dietary iron include red meat, fish, poultry, beans, leaf vegetables, chickpeas, black-eyed peas, fortified bread, and fortified breakfast cereals. The human body absorbs iron in animal products faster than iron in plant product. Iron is also part of the process that governs cell growth and differentiation. Regarding to Fe concentrations, the obtained results as shown in Table (1) and Figure (3) revealed that considerable variation in iron concentration in quail organs was observed. The Fe levels contents was 537.4±115.5 mg/kg in liver samples, 882.7±43.12 mg/kg in the kidney, 362.2±111.9 mg/kg in the heart, 183.4±77.11 mg/kg in the Chest muscle and 162.3±43.12 mg/kg in the leg muscle. Kidney samples had the highest concentration of Fe (882.7mg/kg) and leg muscle had the lowest (162.3 mg/kg). It is important to note that Fe occurred in elevated concentrations in the tissues of the quail birds as compared to those of the other metals, this might be due to their major roles in maintaining the proper physiological functions of the organism. Moreover, Fe has been reported to play an important role as an essential element in all the living system, i.e., from invertebrates to humans and hence, they tend to accumulate high levels of Fe from the surrounding environment [40]. Fe level in quail in present study exceed it values reported previously by [14] who recorded Fe content (2.91–155ug/g) in various parts of chicken samples and chicken products from Turkey; [15] who observed that Fe concentration ranged from 0.98 to 4.65ug/g in liver, kidney and meat of beef (cow), mutton (sheep), caprine (goat) and chicken, from Borno State, Nigeria and [16] who observed that Fe levels were ranged from 41.8 to 109.6 mg/kg in poultry liver samples from Romania and Belgium. On the other hand, our results nearly similar to the results recorded by [35] who found that Fe concentration in the tissues of the quail was relatively higher than that of the chicken tissues and these were 304.95, 859.01, 859.01& & 156.07 mg/kg in the gizzard, lung, liver and pectoral muscle respectively, of quail samples (*Coturnix coturnix japonica*) from Malaysia. Fluctuation levels of metals in the tissues may reflect the diet and mobilization quantities stored in the tissue or last dietary, dermal or respiratory exposure to pollutants [41]. It is worth mentioned that our results are in concordant with that obtained by [42] who found that Fe contents in chickens was higher than other studied meats and meat products. According to [29] Fe has the highest concentration (800-4000 and 7000-1450 ug/kg) in samples of chickens liver and muscle respectively, followed by Cu, Pb, and Cd. The concentrations of the four metals are higher in liver than in muscle tissue samples. This difference may be explained by the fact that offal products (mainly livers) are often used in meat products and an important source of metals. Iron in all studied samples fell within the recommended tolerable levels. The upper tolerable intake level of iron in children (0 months–8 years) and males/females (14–70 years) is 40 and 45 mg d^{-1}, respectively [43]

Manganese is a very common compound that can be found everywhere on earth. It is one out of three toxic essential trace elements, which means that it is not only necessary for humans to survive, but it is also toxic when too high concentrations are present in a human body. A number of studies have shown that manganese has considerable biological significant; it helps prevent cardiac arrest, heart attack, and stroke. But it is quite toxic at high concentrations. Chronic Mn poisoning may result from prolonged inhalation of dust and fume. However, acute toxicity to humans is manifested by a psychologic and neurologic disorder; central nervous system is the chief site of damage [18]. The distribution pattern of manganese in the all samples showed similar trends as iron except that lowest concentration of Mn recorded at chest muscle. Regarding to manganese concentration in quail organs was 4.55±1.35 mg/kg in liver samples, 12.2±0.81 mg/kg in the kidney, 4.29±1.33 mg/kg in the heart, 2.18±1.133 mg/kg in the Chest muscle and 2.53±0.82 mg/kg in the leg muscle. Liver samples had the highest concentration of Mn (4.55 mg/kg) and chest muscle had the lowest (2.18mg/kg) concentration. [35] mentioned that the concentration of Mn ranged from 3.59 to 32.77, it was high in the liver of chicken and quail and this was followed by gizzard; however, the values detected in their study exceeded those previously reported by [14] and [12]. Furthermore, the concentration of Mn was found to be low in chicken compared with that in the body parts of quail, as the latter bird gathered a higher concentration of Mn in its feather followed by gizzard and liver. It is worth mentioned that our results are agreement with that obtained by [42] who found that manganese contents in chickens was higher than other studied meats and meat products. In addition our values were higher than those recorded by [14] who recorded Mn content (0.05–3.91ug/g) in various parts of chicken samples and chicken products from Turkey. But our results were lower than those concentrations (32.77, 8.92, 31.22 &8.59 mg/kg) in the gizzard, lung, liver and pectoral muscle of quail samples (*Coturnix coturnix japonica*) from Malaysia which recorded by [35]. According to the National Research Council of Canada the safe and adequate daily intake levels for manganese recommended range from 0.3 to 1 mg d^{-1} for children up to 1 year, 1–2 mg d^{-1} for children up to age 10, and 2–5 mg d^{-1} for children 10 and older, so our recent data are safe for these aged groups [43].

Concerning zinc, it is constituent of all cells and is an essential trace element, it acts as a co-factor for number of enzymes and it is involved in well over one hundred different reactions in the body. Some of these reactions help the bodies construct and maintain DNA, the molecule that controls how every single part of our bodies is made and works. It is also needed for the growth and repair of tissues throughout our bodies. This extremely important element is used to form connective tissue like ligaments and tendons. Teeth, bones, nails, skin and hair could not grow without zinc. The enrichment of zinc would be benefit for reduction of diarrhea and pneumonia mortality in children. The previous studies presented its biological role in homeostasis, proliferation and apoptosis and its role in immunity and in chronic diseases [44, 45,11]. The concentration of zinc in quail organs was 18.9±14.4 mg/kg in liver samples, 25.5±2.84 mg/kg in the kidney, 25.02±10.7 mg/kg in the heart, 8.11±5.14 mg/kg in the Chest muscle and 9.82±2.84 mg/kg in the leg muscle. Kidney samples had the highest concentration of Zn (25.5 mg/kg) and chest muscle had the lowest (8.11 mg/kg) concentration, these values were found to be less than those recorded by [13] who examine the concentration of trace elements in the selected tissues and organs of domestic Japanese quails (*Coturnix coturnix japonica*) and found that mean level of Zn in liver was 50.607 mg/kg and 51.076 mg/kg in muscle and [35] who found that Zn concentration was 118.9, 29.91, 78.67 and 20.53 mg/kg in gizzard, lung, liver and pectoral muscle respectively, in the tissues of the quail from Malaysia, these concentrations of Zn were higher in comparison to our results of common quails. In addition [16] who observed that Zn levels were ranged from 20.9 to 61.3 mg/kg in poultry liver samples from Romania and Belgium. On the other hand our results was corresponding to [36] who found Zn mean concentration was 24.422 ± 11.032 mg/kg for chicken shawarma in Egypt and [14] who recorded Zn content (7.5–24.3 ug/g) in various parts of chicken samples and chicken products from Turkey. However, results obtained from this study for zinc are also lower than that recorded by [42, 17] and similar to [15] who recorded that Zn concentration for chicken samples (meat and liver) ranged from 2.248 to 9.865mg/kg respectively. Also our values were lower than those reported in Egypt by [22] who found that Zn concentration in the examined meat and sausage samples ranged from 67.9 to 222.3 with mean 137.4± 11.48 and from 19.83 to 65.21 with mean 38.59± 2.96, respectively. With regard to Zn permissible daily intake limit according to the [46] is 0.3-1 mg/kg and that recommended by [37] not exceed 60 mg (for reference adult=60 kg). According to the WHO criteria [47], the permissible concentration of Zinc level is 10-50ppm (mg/kg). In addition, according to [48], normal concentrations of zinc in meat samples are 35–45 mg d^{-1} so it appears that most investigated samples in this study with the allowable levels of zinc.

Table 1: Mean concentration (mg/kg wet weight ± SD) of heavy metals in different tissues of migratory quail (*Coturnix coturnix japonica*).

Element / Samples	Al	Cu	Fe	Mn	Zn
Liver	216.05±211.7	6.64±4.35	537.4±115.5	4.55±1.35	18.9±14.4
Kidney	395.9 ±31.92	3.32±3.68	882.7±43.12	12.2±0.81	25.5±2.84
Heart	120.73±75.44	4.69±9.22	362.2±111.9	4.29±1.33	25.02±10.7
Chest. M.	48.61±25.21	3.08±2.83	183.4±77.11	2.18±1.133	8.11±5.14
Leg. M.	55.73±31.93	2.84±3.68	162.3±43.12	2.53±0.82	9.82±2.84

On the other hand, considerable variations in the mean concentrations and standard deviations of chromium, molybdenum, nickel, lead and strontium (Sr) in the liver, kidney, heart, chest and leg muscles were observed and recorded in Table (2) and Figures (6-10). The concentrations (mg/kg wet weight) of heavy elements in the selected studied organs are varied quietly such as, Cr (2.45-14.51), Sr (1.97-8.65), Pb (1.06-6.17), Ni (0.84-5.42) and Mo (0.23-1.48). The order of the levels of the trace elements obtained from the four different quail organs is Cr > Sr > Pb > Ni > Mo. Chromium is an essential trace element in humans and some animals but in excess, it could have undesirable lethal effect on fish and wildlife [18].

The obtained results, as shown in Table (2) and Figure (6) revealed that considerable variation in chromium concentration in quail organs was 3.93±0.59 mg/kg in liver samples, 14.51±1.63 mg/kg in the kidney, 9.53±10.1 mg/kg in the heart, 2.45±1.38 mg/kg in the Chest muscle and 2.95±1.63 mg/kg in the leg muscle. Kidney samples had the highest concentration of Cr 14.51 mg/kg and chest muscle had the lowest 2.45 mg/kg. Chromium is an essential element helping the body to use sugar, protein and fat, at the same time it is carcinogenic for organisms, excessive amounts of Cr may cause adverse health effects [43]. It is used in metal alloys and pigments and other materials. Low-level exposure can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage, and damage too circulatory and nerve tissue. Food is the main source of chromium intake by man. Cr is fairly evenly distributed throughout the various food groups [22]. On the other hand, [13] examine concentrations of trace elements in the selected tissues and organs of domestic Japanese quails (*Coturnix coturnix japonica)* and found that mean level of Cr in liver was lower (0.227 mg/kg) than in muscle (0.361 mg/kg). These values were lower than our finding. Different levels of chrome shavings were used to evaluate the effects of different aspects on growth performance of quails. The work reveals some significant and highly significant histopathological changes in the heart and gizzard due to chromium. These changes are degeneration of cardiac muscles, splitting of longitudinal muscles, dislocation of nucleus, necrosis, brown atrophy, splitting of striated muscles, pigmentation and severe degeneration in muscles of heart and gizzard [3]. Comparing our results with the previously reported metals data in poultry, it can be noticed that Cr levels were higher than those reported by [14] who recorded 0.01–0.72 ug/g for Cr in chicken samples and chicken product from Turkey and those concentrations (0.009 to 0.033 mg/kg) in poultry liver samples from Romania and Belgium which recorded by [16]. On the other hand our results were closely to that recorded by [34] who found that Cr concentration was 2.75, 1.66, 3.6 and 3.21 mg/kg in the gizzard, lung, liver and pectoral muscle of quail samples (*Coturnix coturnix japonica*) from Malaysia. Also that observed in meat and sausage samples in Egypt, their concentrations ranging from 0.37 to 2.04 ppm (with mean 1.3ppm) and from 0.33 to 3.44 ppm (with mean 1.13ppm), respectively. An adequate Cr intake is believed to be about 25 µg per day for adults and between 0.1 and 1.0 µg for children and adolescents as quoted by [22]. It is worthy to mention that although Cr is an essential trace element in humans and some animals but in excess, it could have undesirable lethal effect on fish and wildlife. The maximum guideline, 12–13 mg/kg stipulated by the United States Food and Drug Administration [18]. Regarding to molybdenum, it is a trace element with known functions (i.e., activities of sulfite oxidase, xanthine dehydrogenase, and aldehyde oxidase) and it is considered as an important micronutrient both for plants and animals; it is considered essential for functioning of nitrate reductase, a key enzyme for nitrogen obsession in leguminous plants. More recent work has indicated that Mo supplementation in human diets may have anti carcinogenic benefits [49]. It is worthy to mention that the concentration of molybdenum in quail organs was 0.72±0.65 mg/kg in liver samples, 1.48±0.06 mg/kg in the kidney, 0.62±0.29 mg/kg in the heart, 0.23±0.08 mg/kg in the chest muscle and 0.28±0.06 mg/kg in the leg muscle. Kidney samples had the highest concentration of Mo 1.48 mg/kg and chest muscle had the lowest 0.23 mg/kg. It is observed that Mo was found in the chest muscle in slight levels compared to other metals. Because no nutritional deficiencies of Mo under practical conditions have been reported in animals, no estimates are available on minimum values for Mo in blood and tissues. Soluble forms of dietary Mo are readily absorbed by animals and cause Mo concentrations in serum, whole blood, milk, liver, and kidney to be increased several fold [50]. Little is known about hazard levels of Mo in wild birds, but the concentration we found in quail organs were nearly similar to those found in the livers of eiders (1.45mg/kg) from Finland and samples from Barrow's goldeneyes and common mergansers from an undisturbed environment (1.41 and 1.34 mg/kg) in Alaska [51, 52].

Concerning to nickel small amounts of it is needed by the human body to produce red blood cells, however, in excessive amounts can become mildly toxic. Long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. Nickel is discharged from many sources like petroleum refineries, electroplating units, steel, fertilizers, automobiles and batteries and nickel mining [11]. Nickel can cause respiratory problems and is a carcinogen as well [38]. The concentration of nickel in quail organs was 1.21±0.07 mg/kg in liver samples, 5.42±0.17 mg/kg in the kidney, 1.61±0.68 mg/kg in the heart, 0.84±0.29 mg/kg in the chest muscle and 0.97±0.167 mg/kg in the leg muscle. Kidney samples had the highest concentration of Ni 5.42 mg/kg and chest muscle had the lowest 0.84 mg/kg. Although the vast industrial use of nickel has led to environmental pollution by the metal and its by-products during production, recycling and disposal, there is little evidence that nickel compounds accumulate in the food chain and it is not a cumulative toxin in animals or in humans [53]. Otherwise, nickel is known as hematotoxic, immunotoxic, hepatotoxic, pulmotoxic and nephrotoxic agent. Nickel and its compounds can cause respiratory problems, carcinogenic to human and are potent inducers of kidney and lung tumors in experimental animals. On the other hand allergic skin reactions are common in individuals who are sensitive to nickel and it induce genotoxicity and oxidative stress through the generation of reactive oxygen species. Also nickel exposure may result in adverse reactions at the sight of contact; gastrointestinal tract, skin or respiratory tract, or systemically; in kidneys, heart and blood. It may lead to pneumonia, pulmonary edema and death. Nickel exposure is also related with cancer development [54, 38, 55, 21]. Comparing our results with the previously reported metals data in poultry, it can be noticed that Ni levels were higher than those reported by [14] who recorded 0.01–2.08 ug/g for Ni in chicken samples and chicken product from Turkey; [35] who found that Ni concentration was 0.39, 0.32, 0.43 and 0.33 mg/kg in the gizzard, lung, liver and pectoral muscle of quail samples (*Coturnix coturnix japonica*) from Malaysia; [16] who observed that Ni levels were ranged from 0.006 to 0.01mg/kg in poultry liver samples from Romania and Belgium and [56] who recorded 0.108, 0.062 &0.062 µg/g for liver, kidney and gizzard of chicken respectively, in Nigeria. In addition, our values were almost nearly to that found by [21] in Egypt who recorded 4.1 & 4.78 µg/g for liver and muscle (breast or leg muscle) samples from Assiut and Qena broiler farms. On the other hand our values were lower than that recorded by [11] who observed that mean concentrations of Ni in liver and meat of chicken *Gallus domesticus* from some selected areas of Pakistan were 7.583 and 4.396 mg/kg. Also they observed that Ni and Pb in liver and meat, and only Ni in blood exceeded the permissible limits. The present study results showed that the concentration of nickel in quail organs is higher compared to the permissible limit of 0.5 ppm [37], and is indicative of nickel contamination in relatively high proportion. But according to Food and Nutrition Board [57] and Egyptian

Organization for Standardization [44] the permissible limit of nickel is 4 and 10 mg/kg in food respectively, so none of tissue samples were found to contain Ni concentration above the permissible limit recommended by these standard guidelines except kidney samples according to [44].

Regarding to lead, it is one of the ubiquitous environmental pollutants, particularly widespread in industrial areas. Birds are exposed to lead from numerous sources as well as from the general environment [58]. Excess lead (Pb) is known to reduce the cognitive development and intellectual performance in children and to increase blood pressure and cardiovascular disease incidence in adults [59]. Regarding to the concentration of lead in quail organs, it was 1.63±0.18 mg/kg in liver samples, 6.17±0.59 mg/kg in the kidney, 2.08±0.8 mg/kg in the heart, 1.06±0.38 mg/kg in the chest muscle and 1.48±0.59 mg/kg in the leg muscle. Kidney samples had the highest concentration of pb (6.17 mg/kg) and chest muscle had the lowest (1.06 mg/kg) concentration. Lead toxicity can affect any organ system many studies show a strong association between lead exposure and renal effects. Both wild and captive birds are at risk of lead toxicities [60]. The later authors stated that considering the major metabolic role of liver and kidneys in birds as a target organ for adverse effects of diclofenac and lead liver and kidney damage caused by single and combined effects of diclofenac and lead in the Japanese quail. While lead impairs many physiological functions in birds including general health, growth, blood, immune, and reproductive systems the liver is important for the metabolism and excretion of lead in bile [61]. Our results agree with [58] who studied the impact of different doses of lead on internal organs of quails, their results showed that generally lead accumulation is highest in liver and kidney while it is low in gonad. Lead affects many organs, physiological functions and cellular and molecular processes in the body. It impedes several cellular signaling processes, the activity of various enzymes and the action potentials in certain nerve cells. The functionality of the thyroid and the adrenal glands is also affected by lead. The kidneys, the blood and the nervous system are the principle target organs. Reproductive effects; miscarriage, male infertility and neonatal morbidity and mortality, may also be seen. Impairment of the immune system may also occur with joint pains related to gout and cardiac fibrosis and myocarditis as consequences [54, 31]. Lead is one of the most toxic elements, because it binds and inactivates essential enzymes. Renal, gastrointestinal, nervous and haemapoietic systems are affected by the lead intoxication [62]. Different levels of lead were recorded by different authors at different countries, the mean value of Pb in the present study was higher than that reported by [14] who recorded 0.01–0.40 ug/g for Pb in chicken samples and chicken products from Turkey; [35] who found that pb concentration was 0.75, 0.73, 0.55 and 0.47 mg/kg in the gizzard, lung, liver and pectoral muscle of quail samples (*Coturnix coturnix japonica*) from Malaysia and [16] who observed that pb level was 0.006 mg/kg in poultry liver samples from Romania and Belgium. In Egypt different levels were reported by [36] in chicken shawerma (1.48 ±1.771 ppm); [21] recorded 2.75 & 2.8 µg/g for liver and muscle (breast or leg muscle) samples from Assiut and Qena broiler farms and by [22] who found that Pb concentration in the examined meat and sausage samples ranged from 0.45 to 2.81 mg/kg and from 1.892 and 1.756 mg/kg. In addition those recorded by [11] who observed that mean concentrations of Pb in liver and meat of chicken *Gallus domesticus* from some selected areas of Pakistan were 1.234 and 1.797 mg/kg. On the other hand, it was corresponding with [63] who recorded pb concentration (6.94± 4.63µg/ kg) in chicken samples from Spain and lower than [42] who observed pb concentration (15.43±1.22 µg/g) in sausage from Saudi Kingdom. In the present study Pb concentration was ranged from 1.06 to 6.17 mg/kg. According to [47] and [59] which established limits for Pb content of 0.3 mg/kg fresh weight basis, the examined samples in this study were above the permissible limit, so our results show serious Pb contamination of quail organs. But the [46] suggested 2 ug/g wet weights as guideline limit for Pb in food, the levels in this study were below this limit except kidney samples. However, our result is in agreement with some reports which tend to show that internal organs of poultry as liver and kidney accumulate Pb more than muscle. In addition, the significantly higher Pb accumulation in parenchymatous organs was confirmed by [64] who detected the highest Pb concentration in kidneys and livers in wild animals.

Strontium is considered as an essential element involved in Ca and P management for animals. Nevertheless, the possibility that Sr is essential has not been confirmed. It is non toxic, since it readily accumulates in bone tissue [22]. The concentration of strontium in quail organs was 3.33±0.9 mg/kg in liver samples, 8.65±1.17 mg/kg in the kidney, 3.39±0.89 mg/kg in the heart, 1.97±1.43 mg/kg in the Chest muscle and 2.69±1.17 mg/kg in the leg muscle samples. Kidney samples had the highest concentration of Sr 8.65 mg/kg and chest muscle had the lowest 1.97 mg/kg concentration. According to [65] mean concentrations of strontium in samples (liver, kidney and heart) of sheep were 13.63, 12.45 and 10.87 in summer, while such values were 2.04, 2.19 and 2.41 ppm during winter respectively. But according to [31] Sr concentration in samples (liver, kidney and heart) of goats were 4.14, 3.67 and 3.34 in summer, while such values were 2.42, 2.60 and 3.21 ppm during winter respectively. Values in this study were extremely greater than that reported by [66] for muscle, liver and kidney (0.13, 0.11and 0.18 mg/kg dry weight) of red deer. On the other hand Sr mean concentration in meat and sausage samples examined in Egypt was 2.47 and 11.15mg/kg respectively, [22].

Table 2: Mean concentration (mg/kg wet weight ± SD) of heavy metals in different tissues of migratory quail (*Coturnix coturnix japonica*)

Element / Samples	Cr	Mo	Ni	Pb	Sr
Liver	3.93±0.59	0.72±0.65	1.21±0.07	1.63±0.18	3.33±0.9
Kidney	14.5±1.63	1.48±0.06	5.42±0.17	6.17±0.59	8.65±1.17
Heart	9.53±10.1	0.62±0.29	1.61±0.68	2.08±0.8	3.39±0.89
Chest. M.	2.45±1.38	0.23±0.08	0.84±0.29	1.06±0.38	1.97±1.43
Leg. M.	2.95±1.63	0.28±0.06	0.97±0.17	1.48±0.59	2.69±1.17

It is worthy mentioned that the values of correlation coefficients between metal concentrations in quail tissues are given in Table 3. A large number of significant associations between essential metals were found in the different tissues and between essential and non essential metals.

These interactions perhaps indicate that mineral balance in the body is regulated by important homeostatic mechanisms in which toxic elements contend with the essential metals, even at low levels of metal exposure. The knowledge of these correlations may be essential to appreciate the kinetic interactions of metals and their implications in the trace metal metabolism [67, 35].

Table 3: Correlation between metals concentration in different tissues of migratory quail (*Coturnix coturnix japonica*)

	Al	Cu	Fe	Mn	Zn	Cr	Mo	Ni	Pb	Sr
Al	1.000									
Cu	0.196	1.000								
Fe	0.996**	0.249	1.000							
Mn	0.963**	0.046	0.953**	1.000						
Zn	0.742*	0.404	0.784*	0.725	1.000					
Cr	0.811**	0.073	0.822**	0.902**	0.867*	1.000				
Mo	0.986**	0.128	0.986**	0.984**	0.807*	0.896*	1.000			
Ni	0.911**	0.198	0.895**	0.988**	0.665	0.909**	0.946**	1.000		
Pb	0.911**	0.193	0.894**	0.981**	0.674	0.912**	0.948**	0.998**	1.000	
Sr	0.942**	0.117	0.925**	0.996**	0.696	0.901**	0.969**	0.993**	0.996**	1.000

** Correlation is significant at the 0.01 level, * Correlation is significant at the 0.05 level.

4. Conclusion

Generally water and food consumption are the major pathway for human exposure to heavy metals and so threatens the health of the population. The findings of this study have shown that migratory common quail has different capabilities to accumulate certain metals in their tissues. The level of heavy metals and trace elements in migratory common quail tissues were determined and assessed by comparing the results with the permissible limits. The results indicated variation in the concentrations of the measured heavy metals and trace elements between samples. With consideration, essential elements occur in high levels compared to the non-essential elements in the tissues of these migratory birds. Meanwhile, kidney is the tissue which has the highest level of most metals, that is may be as mentioned at previous studies that kidney may accumulate substantial amounts of heavy metals followed by liver, which making them a suitable metals indicator in internal tissues of birds. Also, liver was found to have gathered higher metal concentrations than muscle in the birds that because it is consider as a storage organ and detoxifier. In particular, quail undertaken in this study was not associated with the increased contents of toxic metals in their muscles and viscera which could be considered as for human consumption. Most estimated metals indicated no health risk as their values were within the permissible tolerable levels cited by locals and internationals committees except Pb and Cr, the tissues showed higher levels of them. However, in case of accidents, when large amounts of these chemical substances are spread in the environment, heavy metals contaminations represent a real risk for the consumer. The levels are also comparable to recently published results for other countries. In general, metal concentrations in our poultry samples were sometimes lower than those reported in other countries, in recent years.

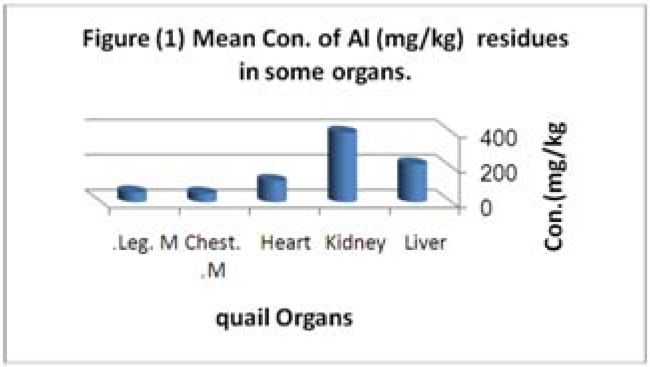


Figure (2) Mean Con. of Cu (mg/kg) residues in some organs.

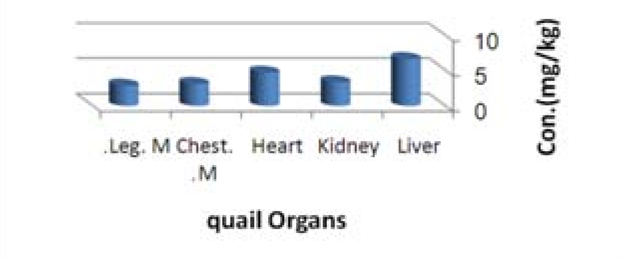


Figure (3) Mean Con. of Fe (mg/kg) residues in some organs.

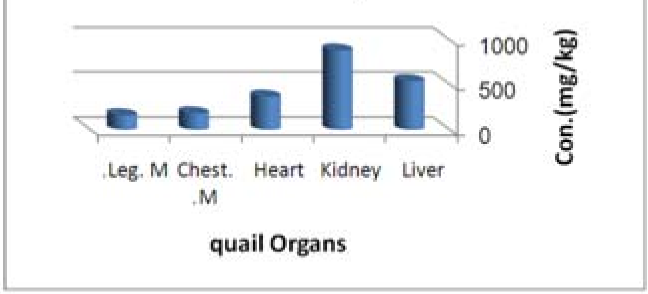


Figure (4) Mean Con. of Mn (mg/kg) residues in some organs.

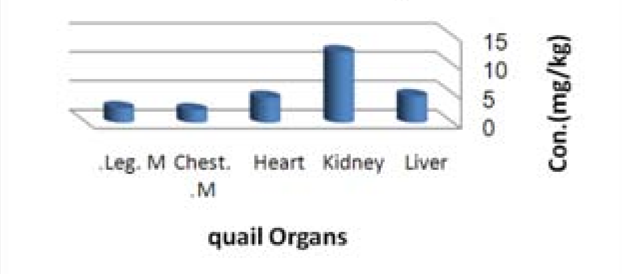


Figure (5) Mean Con. of Zn (ppm) residues in some organs.

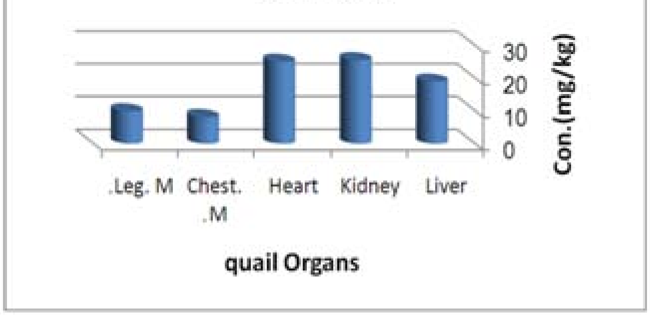


Figure (6) Mean Con. of Cr (mg/kg) residues in some organs.

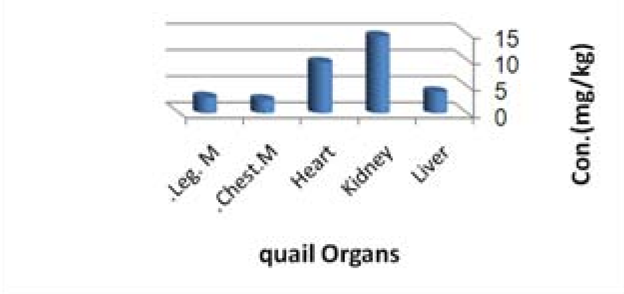


Figure (7) Mean Con. of Mo (mg/kg) residues in some organs.

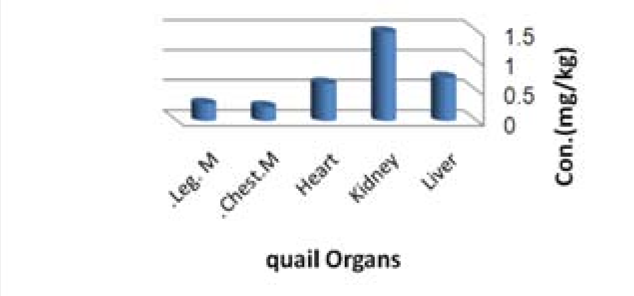


Figure (8) Mean Con. of Ni (mg/kg) residues in some organs.

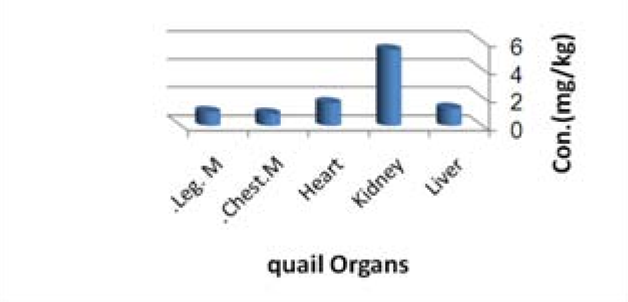
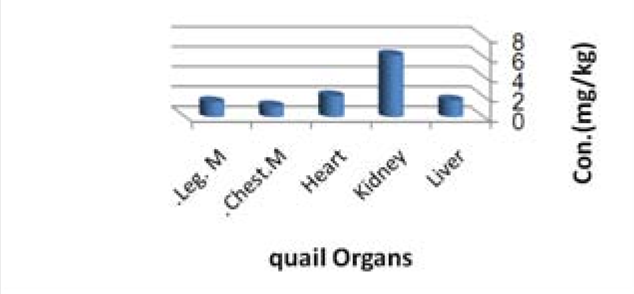
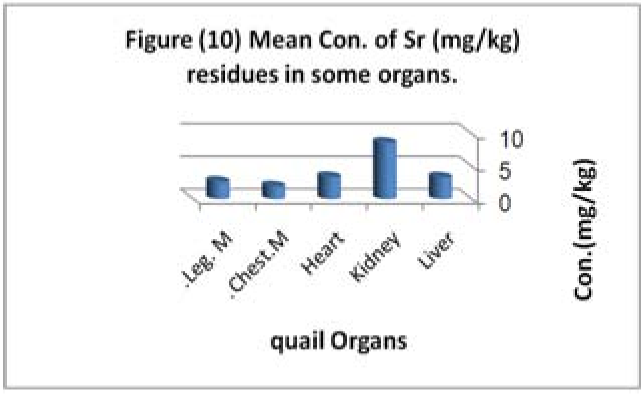


Figure (9) Mean Con. of Pb (mg/kg) residues in some organs.





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