DETERMINATION OF CADMIUM AND COPPER LEVELS IN READY-TO-EAT SHAWERMA IN SOHAG CITY

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ABSTRACT

Objective: **Food safety is a major concern at present. The increasing demand of food safety has accelerated regarding the risk associated with food consumption contaminated by heavy metals. Ready-to-eat foods make up a significant proportion of the daily food intake. Metals are non-decomposable and are recognized as main environmental contaminants causing cytotoxic, mutagenic and carcinogenic effects in human and animals. Thirty seven random samples of ready-to-eat shawerma were collected from different restaurants located at Sohag city to determine their cadmium and copper contents. Cadmium and copper were determined using Atomic Absorption Spectrophotometer. The analyzed shawerma samples revealed that their content (ppm) for cadmium was ranged from 0.127-3.622 with mean of 0.899± 0.114. while copper content (ppm) was ranged from 1.560-31.800 with mean of 4.093±0.829. In comparing the obtained results with the maximum permissible limits set by different Organizations, all examined samples showed high Cd level (0.898 ppm) than that recommended by EOSQC (1993) as 0.1 ppm; WHO (2000) as 0.1 ppm; and European Commission (2008) as 0.05 ppm while only 4 samples (10.818%) exceed the limit of EOSQC (2005) as 2 ppm. For copper, many samples exceed these limits where 1 sample (2.702%) higher than EOSQC (1993) limit 15 ppm and ESCDA (2002) limit 20 ppm and 2 samples (5.405%) were higher than European Commission (2006) limit 10 ppm.**

Key words: *Fast foods - ready to eat shawerma - cadmium - copper - pollution.*

INTRODUCTION

Environmental exposure through food is considered as an important source of heavy metal in developed countries (Johri et al., 2010). Heavy metal pollutants can contaminate the products during processing through raw materials, cooking utensils, food packaging and spices used during processing of meatball, corned beef, beef burger and sausages (Raikwar et al., 2008). Street food vendors obtain their pots and utensils from both formal and informal manufactured using scrap metal obtained from diverse sources such as derelict cars, car batteries and industrial machinery Heavy metals from these pots could reach into the food (Mensah et al., 2002).

According to the Agency for Toxic Substances and Disease Registry (ATSDR, 1999), foods account for more than 90 percent of human exposure to cadmium (Cd) through eating foods containing it; low levels in all foods but highest in liver and kidney meats. Cd is a very toxic

heavy metal, which accumulates inside the body particularly kidneys leading to kidney stones. Generally, the ingestion of Cd may result in acute gastroenteritis manifested by sudden onset of vomition, diarrhea and abdominal pain. Moreover, Cd poisoning may result in a Itai-Itai disease which is characterized by severe pain, soft bones and death which may occur as a result of renal failure (Kazantzis, 2004).

Cadmium is present in various materials as anticorrosive coating, pigments (specially red and yellow), stabilizers, material galvanization, battery components (nickel-Cd), and eliminated gas from motor vehicles, phosphate fertilizers, pesticides, plastics and glass. These Cd contamination sources are constantly introduced into environment (soil, water and air) and can poisoning animals when ingested and/or inhaled (Patra et al., 2005; Miranda et al., 2006; Swarup et al., 2007).

Cadmium is a mineral element highly toxic to animals and humans (Swarup et al., 2007; Stanevičinė et al., 2008) and not essential to physiological and biochemical functions (El-Sharaky et al., 2007; Djuić-Ćosić et al., 2008). Relatively low cadmium exposure may give rise to skeletal damage, evidenced by low bone mineral density (osteoporosis) and fractures (Alfven et al., 2000; Nordberg et al., 2002). Animal experiments have suggested that cadmium may be a risk factor for cardiovascular disease (Jarup et al., 1998).

The IARC has classified Cd as a human carcinogen (group I) on the basis of sufficient evidence in both humans and experimental animals (IARC, 1993). Cd can be fetal in cases of acute poisoning, affect avian population by altering reproductive success behaviour, immune response and physiology, and may induce cancer in cases of chronic exposure (Burger and Gochfeld, 2000). Cd is a cumulative toxic agent with a biological half-life of 10-30 years. Accurately, Cd acts on sulphhydryl groups of essential enzymes and also binds to albumin, phospholipids and nucleic acids, interferes with oxidative phosphorylation and replaces zinc in enzymes so changing their activities (Bernard, 2004).

Copper (Cu) is an important constituent in a number of different enzymes in man and animals; it accumulates mostly in muscle and liver acting as essential element for haemoglobin formation and hair keratin. However, it may be toxic for both animals and humans causing liver cirrhosis and liver debilitating condition in continuous ingestion. Accordingly, ingestion of excessive doses of Cu may lead to Wilson's disease which manifested by destruction of nerve cells, liver cirrhosis, aschitis edema and hepatic failure (Irfana et al., 2004).

The physiologic roles of essential metals are well known e.g. Cu (amine oxidases, caeruloplasmin, dopamine hydrolase and collagen synthesis)(Marias and Blackhurst 2009). The physiologic roles of essential metals are due to the fact that these metals are components of enzymes and proteins. The deficiency of these elements could induce disease conditions e.g. Cu deficiency is known to induce hypertension, increase blood cholesterol (hypercholesterolemia) and low density lipoproteins fraction increment in blood which add to the conditions favouring heart attack. The intake of essential metals above threshold limits could cause toxicity problems (Singh and Taneja, 2010).

Copper is an essential trace element for animals and man. It is released into the environment primarily via mining, sewage treatment plants, solid waste disposal, welding and electroplating processes, electrical wiring materials, plumbing supplies (pipes, faucets, braces, and various forms of tubing) and agricultural processes. It is a common component of fungicides and algaecides. Agricultural use of Cu for these purposes can result in its presence in soil, ground water, farm animals (grazing animals like cows, etc.) and many forms of produce (ATSDR, 1990).

Since these metals are bio-accumulated in the tissues of plants, animals and so inside the human body resulting in many disorders and toxicity (even in low doses in toxic metals or large doses in essential metals). Thus, this study aimed to determine the level of cadmium and copper in ready-to-eat meals of shawerma.

MATERIALS AND METHODS

Samples: Thirty Seven random samples of ready-to-eat shawerma (of meat origin) were collected from different restaurants located at Sohag city. The samples were packed in polyethylene bags and directly transferred to the laboratory for determination of cadmium and copper.

METHODS

1- Digestion of samples: One gram of each sample was macerated by sharp scalpel in a screw capped tube. Five milliliters of the digestion mixture (60 nitric acid 65% and 40 ml perchloric acid 70-72%) were added to the tissue sample. The tubes were tightly closed and the contents were vigorously shacked and allowed to stand overnight. Then the tubes were heated for 3 hours in water bath adjusted at 70°C to ensure complete digestion of the samples. Finally the tubes were cooled at room temperature and then diluted with 25 ml distilled water, and filtered by using filter paper. The filtrate kept at room temperature until analyzed for cadmium and copper contents (Khan et al., 1995).

2- Estimation of metals: Cd and Cu were determined in the central laboratory of Chemistry Department, faculty of Science by using Atomic Absorption Spectrophotometer (Buck model 210 VGP)(Buck Scientific Inc. East Norwalk, CT (USA)(Agemain et al., 1980).

Calculation and Quantitative determination of heavy metals: The concentrations of heavy metals were calculated as ppm (mg/kg) on wet weight according to the following equation: Metal concentration (mg/kg) wet weight = CxV/W Where C is the concentration of the metal in the sample extract as determined by AAS (mg/l), V is the volume of the extract (ml) and W is the weight of the sample (g).

3- Statistical analysis: Data obtained were statistically analyzed using descriptive statistics according to SPSS 14 (2006).

RESULTS

The results were summarized in table (1 and 2) and figures (1-3). Cd (ppm) was ranged from 0.127-3.622 with mean of 0.899 ± 0.114 while Cu content (ppm) was ranged from 1.560-31.800 with mean of 4.093 ± 0.829 (Table 1 and Fig. 1).

Table 1: **Cd and Cu levels (mg/kg) in the analyzed ready-to-eat shawerma samples.**

Detected metal	Number of investigated samples	Minimum-Maximum (mg/kg, ppm wet weight)	Mean ± S.E.	Maximum permissible limit (ppm) of EOSQC (1993)
Cadmium	37	0.127 – 3.622	0.899 ± 0.114*	0.1
Copper	37	1.560 – 31.800	4.093 ± 0.829*	15

***: Means highly significant different from that of EOSQC limit at $p \leq 0.05$.**
EOSQC: Egyptian Organization for Standardization Quality and Control.

Table 2: **Number and percentage of samples of shawerma that exceed the maximum permissible limits set by different authorities.**

Detected metal	No. of samples	Number of samples and their percentage that exceed the MPLs (mg/kg) set by different authorities.				
		EOSQC (1993)	**EOSQC (2005)**	**WHO (2000)**	**FSCDA (2002)**	**European Commission (2006)**
Cadmium	37 (100%)	0.1* 37 (100%)	2* 4(10.811%)	0.1* 37(100%)	--------	0.05* 37 (100%)
Copper	37 (100%)	15* 1(2.702%)	--------	-------	20* 1(2.702%)	10* 2(5.405%)

***: Maximum permissible limits (MPLs)(mg/kg) set by different authorities.**
EOSQC: Egyptian Organization for Standardization Quality and Control.
FSCDA: Food Stuffs Cosmitics and Disinfectant Act.
WHO: World Health Organization.

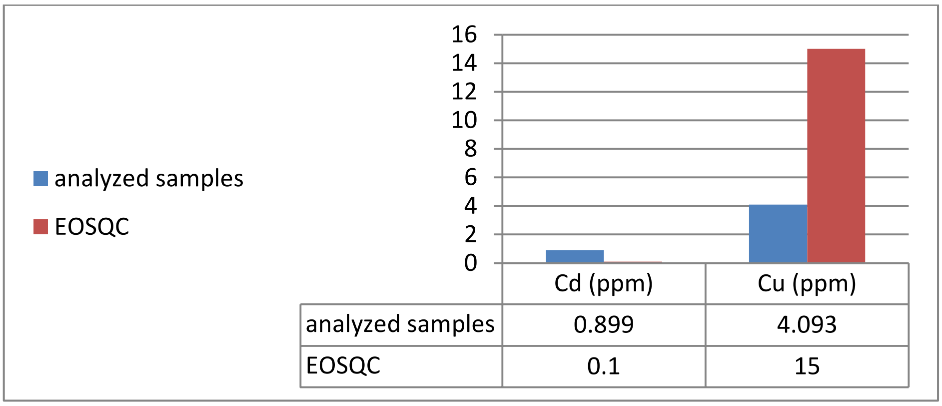

Fig. 1: **Cadmium and copper levels (mg/kg wet weight) in examined shawerma.**

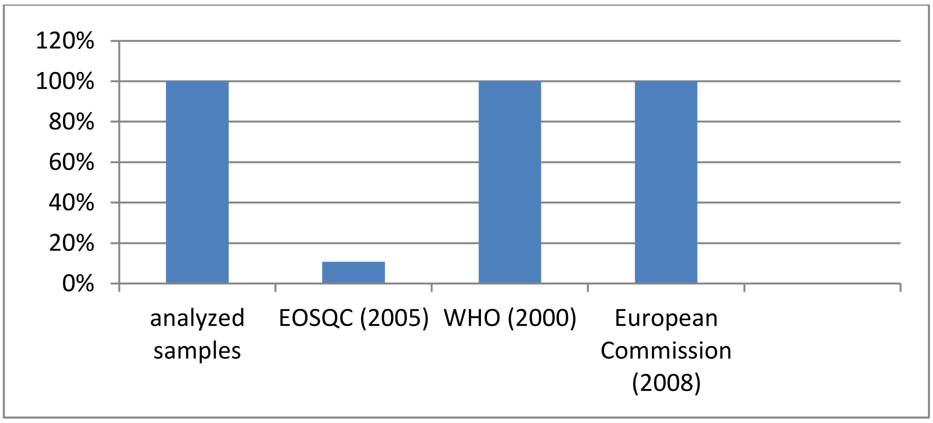

Fig. 2: **Percentage of the examined samples of shawerma that exceed the maximum permissible limits of Cd set by different authorities.**

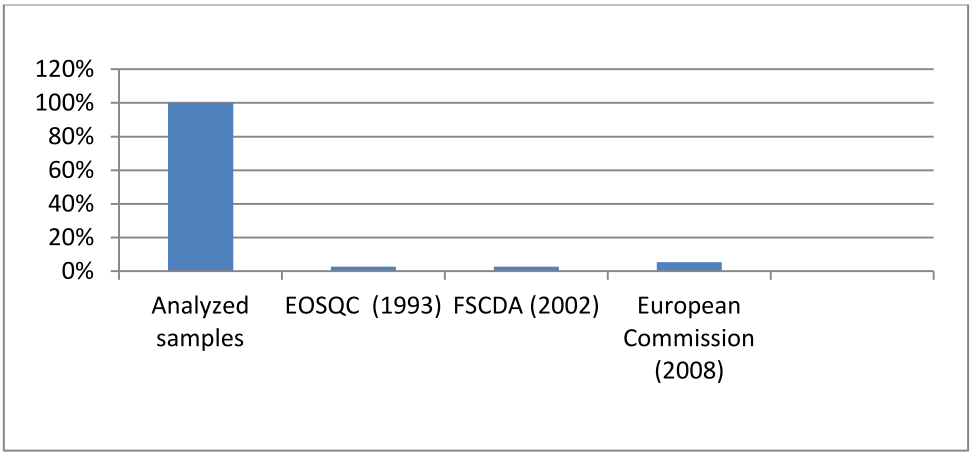

Fig. 3: **Percentage of the examined samples of shawerma that exceed the maximum permissible limits of Cu set by different authorities.**

DISCUSSION

Heavy metals are potentially harmful to most organisms even in very low concentrations and have been reported as hazardous environmental, as toxic heavy metal can cause dermatological diseases, skin cancer and internal cancers (liver, kidney, lung and bladder), cardiovascular disease, diabetes, and anemia, as well as reproductive, developmental, immunological and neurological affects in the human body (Johri et al., 2010). Nowadays, the environmental pollution by heavy metals is considered as one of the most serious problems in the world. Emissions of heavy metals to the environment occur via a wide range of pathways, including air, water, soil, natural and anthropogenic sources, rapid industrialization, increase in road traffic, consumer habits and life style (Voutsaand and Samara, 2011).

Food is a vital substance required by all organisms for the sustenance of life, and its associated functions, such as growth, development, and maintenance of the body (Iweala et al., 2014 and Izah et al., 2015). Most food materials are derived mainly from plants (fruits, vegetables, cereals, tuber, grains, etc.) and animals (Izah et al., 2016). Food provides the body with essential resources, such as vitamins and minerals. Foods are typically classified according to readiness and convenience to consumption. Some are consumed without further preparation (i.e., ready-to-eat food) and the category that requires further processing before consumption. The consumption of ready-to-eat (RTE) food has increased. Iwegbue et al. (2013) attributed the increase in the consumption of ready-to-eat food to increased mobility, itinerary workers, and low home-centered activities.

Shawerma is among the most popular of all snacks in the Arab world. Most often made from beef meat. It is cut into thin slices and arranged on a vertical skewer from which individual servings are shaved. A popular way to serve shawerma is in sandwich form, rolled into a flat round of bread and garnished with finely chopped tomatoes, parsley, lettuce, onions, and tahini (sesame) sauce.

CADMIUM

The analysis of shawerma samples revealed a cadmium level ranged from 0.127 to 3.622 mg/kg wet weight with a mean of 0.898 (table 1 and fig. 1). In comparing the obtained results with the maximum permissible limits set by different organizations, all examined samples showed high Cd level (0.898 ppm) than that recommended by EOSQC (1993) as 0.1 ppm; WHO (2000) as 0.1 ppm; and European Commission (2006) as 0.05 ppm while only 4 samples (10.818%) exceed the limit of EOSQC (2005) as 2 ppm (Table 2 and Fig. 2).

Added spices such as pepper, mustard and other common spices have been reported to contain significant quantities of some heavy and trace metals (Gupta et al., 2003). The high significant differences between the examined samples could be attributed to different breeding environments, variations in the daily sources of food, and the individual inherent capacity of the animals to excrete heavy metals. However, the higher Cd concentrations in the examined RTE samples than in the examined fresh samples may be due to adding cooking spices and herbs (garlic, onion and pepper) which contain cadmium and pesticides may be a source of cadmium as recorded by (Krejpcio et al., 2007).

Presence of Cd in foods poses grave danger to public health and safety (Mohammed et al., 2013). Cd is toxic to virtually every system in the animal body. Though Cd is almost absent in human body at birth, it accumulates with age. There are reports in which Cd accumulated in the kidney and liver over a long time that interacts with a number of minerals mainly zinc (Zn), iron (Fe), Cu and selenium (Se) due to chemical similarities and competition for binding stage (Hussain et al., 2012). It is also reported that Cd can affect calcium (Ca), phosphorus (P) and bone metabolism in both industrial and people exposed to Cd in general environment.

In this study cadmium levels (ppm wet weight) in shawerma were lower than that obtained by Shaltout et al. (2003) as 1.741-3.861 with a mean value of 2.185, but higher than that recorded by Fatin (1998) who revealed the mean value of Cd in shawerma in Kalyobia governorate was 0.092±0.008 ppm, by Sharkawy and Amal (2003) as 0.067 ± 0.006, by El-Tawwab (2004) as 0.195-0.281 and 0.241±0.004, Hala and Shireen (2008) as 0.338±0.435 ppm, Essa et al. (2007) as 0.010±0.005, Elham-Elshewey et al. (2015) as 0.03-0.58 (0.31±0.03) for rural locations and 0.04-0.79 (0.41±0.05) for urban areas in Kalubia Governorate, Egypt.

The development of industry and the increasing number of vehicles become some factors which increase pollution. The advances of technology, industrial activities and the increase in road traffic have led to a significant increase in environmental contamination. The presence of some metal pollutants is everywhere, especially Cd, this metal pollutant spread out into animal rations and food chain, thus it may increase the possibility of toxic effects in humans and animals (Farmer and Farmer, 2000; Nnorom et al., 2007; Javed et al., 2009).

Iwegbue et al. (2008) detected Cd in chicken meat in different locations in southern Nigeria was ranged from of 0.01-1.27 mg/kg and Gonzalez-Weller et al. (2006) determined that of cadmium 1.68 ppm in chicken meat from Spain markets.

The levels of metals in foods are of great importance because of the wide role of metal ions in health and diseases which include the requirement for intake of essential trace elements to the

toxicity associated with metal overload (Hague et al., 2008). Cd cannot be tolerated at low concentrations because they are exceptionally toxic to human (Suppin et al., 2006). For example, the toxicity of heavy metals could be by the displacement of physiologically appropriate metal: Cd can replace Cu and Fe in cytoplasmic and membrane proteins. Especially in divalent form, the free metal ions can promote the generation of superoxide and hydroxyl radical which, in turn, can lead to oxidative damage of lipids, nucleic acids and proteins (Marias and Blackhurst, 2009). Cd has been linked to skeletal damage (Jarup, 2003).

The presence of heavy metal residues particularly in fast foods is potentially hazardous to human specially children.

COPPER

Copper content in the examined shawerma samples was ranged from 1.560 to 31.800 with mean as 4.093±0.829 mg/kg (ppm) (table 1, fig.1). When comparing these results with the permissible limits set by different authorities for copper showed that many samples exceed these limits where 1 sample (2.702%) higher than EOSQC (1993) limit 15 ppm and FSCDA (2002) limit 20 ppm and 2 samples (5.405%) were higher than European Commission (2006) limit 10 ppm (Table 2, Fig. 3).

Copper is a common component of fungicides and algaecides and released to environment from sewage, plumbing supplies (pipes, tubes) so leads to their presence in soil, ground, water, and farm animals (ATSDR, 1990). Copper is widely distributed in nature, being used in its various forms, and Cu sulphate is used as pesticides, fungicides and herbicides (Lebre et al., 2005).

This result may be attributed to widely use of Cu in cooking utensils and water distribution systems, as well as fertilizers, bactericides, fungicides, algicides and antifouling paints. It is also used as animal feed additives and growth promoters, as well as for disease control in livestock and poultry (WHO, 1998).

The mean Cu concentrations (mg/kg wet weight) in examined ready-to-eat shawerma in this study was 4.093±0.829. This level is higher than that observed by Essa et al. (2007) who found that Cu concentrations in examined ready-to-eat sandwiches of shawerma was 0.954 ± 0.170 ppm, Ferreira et al. (2005) who detected copper mean value in chicken meat thigh 0.07 and breast 0.04 (mg/100gm), by Iwegbue et al. (2008) from different locations in Nigeria found that copper level was ranged from 0.01-5.15ppm in chicken meat and by Hala and Shireen (2008) who found The mean value of copper was 2.854 ± 2.642 ppm in shawerma.

Copper, Mn, and Zn are added to poultry diets (premix) to enhance their weight gain and disease prevention (Sims and Wolf, 1994; Jackson et al., 2003). The addition of copper sulfate (125 or 250 mg kg -1) to broiler chicken diet enhances weight gain and feed efficiency (Miller et al., 1986) while Fe and Zn are supplemented to balance the ratio (Tazisong et al., 2005).

Copper is known to be essential at low concentrations but it is toxic at high levels. Accordingly, ingestion of an excessive dose of Cu may lead to severe nausea, bloody diarrhea, hypertension and jaundice. Moreover, chronic Cu poisoning may result in what is known

"Wilson's disease" which manifested by destruction of nerve cells, liver cirrhosis, ascitis, oedema and hepatic failure (Gosel and Bricker, 1990).

The occurrence of Cd and Cu in this type of food may results from environmental contamination like gases, fumes and particulate materials containing metal which result from emission due to industrial activities, from contaminated air, water, and soil (which absorbed by plants used directly by human or used as a feed for animals) or from the raw (uncooked) materials used for the processing of food.

So, the continuous consumption of sandwiches contaminated with cadmium exceeding the safe permissible limits may result in a potential health hazards through progressive irreversible accumulation in human body.

For obtaining these ready-to-eat meat meals with a minimal metal pollution:

- The manufacturing of such products should be done inside the restaurants and shops away from the motor vehicle exhaust especially at the areas of high traffic density.

- The presence of contaminants must be reduced more thoroughly wherever possible by means of good manufacturing or agricultural practices, in order to achieve a higher level of health protection, especially for sensitive groups of the population.

- Due to the fact that some heavy metals have the tendency to cause irreparable damage to the human body, their concentration in ingested ready to eat fast foods need to the monitored.

- Applying food safety standard on a product is very important because it relates closely to human's health. Good food product has a high nutritional quality, as well as free from physical, chemical and biological contaminations.

- Any maximum level adopted at Egyptian Standard level will have to be reviewed regularly to take account of the advance of scientific and technical knowledge and improvements in manufacturing or agricultural practices with the objective of achieving steadily decreasing levels.

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قياس مستوي الكادميوم والنحاس في الشاورما الجاهزة للأكل في مدينة سوهاج

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الملخص :

في هذه الدراسة تم استخدام عدد ٣٧ عينة شاورمه جاهزة للأكل تم جمعها من المطاعم المنتشرة في مدينة سوهاج . تم تحليل هذه العينات بواسطة جهاز الامتصاص الذري الطيفي بقسم الكيمياء كلية– العلوم– جامعه أسيوط وذلك لقياس مستوي الكاديوم والنحاس بها.

وقد أظهرت النتائج أن مستوي (١) الكادميوم: يتراوح من ١٢٧و. الي ٦٢٢و٣ بمتوسط قدره ٨٩٩و٥±١١٤و. جزء في المليون.(٢) النحاس: يتراوح من ٥٦٠و١ الي ٨٠٠و٣١ بمتوسط قدره ٩٣٠و٤±٨٢٩و. جزء في المليون. وبمناقشة هذه النتائج تبين: – أن مستوي الكادميوم في كل العينات يزيد عن الحدود المسموح بها من هيئة المقاييس المصرية للجودة والمواصفات لأعوام ١٩٩٣، ٢٠٠٥م. تم مناقشة هذا النتائج لما تشمله من خطورة علي الإنسان نتيجة الاستمرار في استهلاك هذا النوع من الطعام لما فيه من النسب العالية من الكادميوم التى تمثل خطراً على المستهلكين فى مختلف المراحل العمريه.

– بالنسبة الي عنصر النحاس فقد تبين ان مستواه اقل من الحد المسموح به في هيئة المواصفات والجودة المصرية لعام ١٩٩٣ والاتحاد الأوربي لعام ٢٠٠٦ مما يعني ان استهلاك هذا النوع من الطعام بصفة مستمرة يؤدي الي نقص في عنصر النحاس من الجسم ان لم يمكن هناك توزن في هذا العنصر من المواد الغذائية الاخري وهذا بدوره يؤدي الي اضطرابات وظيفية التي تنتج عنها بعض الأمراض وخاصة في الأطفال والسيدات الحوامل والرجال كبيري السن.

لذلك توصي الدراسة بما يلى:

– عمل فحص دوري لهذه الأطعمة للحد من الملوثات البيئية وخاصة عنصر الكادميوم لما قد يسببه من إمراض كبيرة علي مستهلكي هذا النوع من الغذاء.

– الالتزام بالقواعد والمواصفات التى تضعها الهيئات المنظمه فى هذا الشأن من حيث النسب المسموح بها من تلك العناصر فى مثل هذه الانواع من الاطمه.

– أن تكون المواد المستخدمه فى هذه الأطعمه (لحوم أبقار أو دواجن ، متبلات ، اضافات غذائيه، بهارات) خاليه من العناصر الثقيله مثل الكاميوم أو على الأقل فى الحدود المسموح بها مصرياً وعالمياً.