بسم الله الرحمن الرحيم

**Sudan University of Science and Technology**
**College of Graduate Studies**

# Assessment of concentration of some heavy metals in fresh meat and sausage of beef, goat and camel in Khartoum State Sudan

تقييم تركيز بعض المعادن الثقيلة في اللحم الطازج وسجك لحم الابقار, الماعز والجمال في ولاية الخرطوم - السودان

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بسم الله الرحمن الرحيم

قال تعالى :

(وَمَا أُوتِيتُمْ مِنْ الْعِلْمِ إِلاَّ

قَلِيلاً)

صدق الله العظيم

سورة الإسراء الآية 85

# شكر وعرفان

الشكر والفضل والمنة أولاً وآخراً لله وحده أن يسر هذا العمل فله الشكر عدد ما شكره الشاكرون , شكراً بكل معنىً ينصرف إليه إسمه .

ثم من بعد يطيب لنا أن نتقدم بخالص الشكر وأعطره لكل من مد لي يد المساعدة والتشجيع في بحثي هذا إبتداءً بالأب الفاضل والمعلم البروفيسور:داوؤد الزبير احمدالذي تشرفت بتعيينه مشرفاً ..

ولا ننسى أن نقدم شكري إلي د.محمد سرالختم, د.سهام عبدالوهاب, أ.هدي زين العابدين

واخيرا اشكر لكل من مد لي يد العون

لكم جميعاً الشكر والتقدير

وفاء

# الإهداء

الى معلم البشرية الأول رسولنا الأعظم , سيدنا محمد صلى الله عليه واله وسلم.

**الي ابي :**

من علمني العطاء بدون انتظار .. إلى من أحمل أسمه بكل افتخار ... الي من أسكنني قلبه وعلمني السلام قبل الخصام.

**إلى أمي:**

الي ملاكي في الحياة .. إلى معنى الحب وإلى معنى الحنان والتفاني .. إلى بسمة الحياة وسر الوجود.. إلى من كان دعائها سر نجاحي وحنانها بلسم جراحي إلى أغلى الحبايب

**إلى زوجي:**

إلى صاحب القلب الطيّب .. إلى صاحب النفس الأبيّه .. إلى صاحب الابتسامة الفريدة .. إلى من حارب وساهم الكثير مِن أجلي.

**الي ابنتي :**

هذا من اجلك ياحبيبتي ... يانبض قلبي

# Abstract:

This study was conducted in the college of Animal Production Science and technology - Sudan University of Science and Technology. During the period February 2016 to May 2017 to investigate the concentration of lead, cadmium, mercury, arsenic, nickel, chromium, zinc, manganese, copper and iron in fresh meat and sausage of beef, goat and camel, and conformity with some international standards. The samples were collected from some public market in Khartoum state and processed in laboratory of meat science and technology – collage of animal production science and technology- Sudan University of Science and Technology. Analysis was done in Environmental and Natural Resources Desertification Research Institute Laboratory.

The results showed there was no significant difference between type of fresh meat and sausage in lead, cadmium, mercury and arsenic, the level of lead, cadmium, mercury and arsenic in fresh beef, goat and camel meat was lower than detection limits 0.001. The results showed there was high significant difference ($p \leq 0.01$) in chromium, zinc, nickel and iron between type of fresh meat and no significant difference between type of fresh meat in manganese and copper. The results showed the concentration of essential metals; Cr, Mn, Zn, Ni, Cu and Fe in fresh meat of beef, goat and camel meat as (0.52, 0.32 and 0.38), (0.08, 0.25 and at detection limits), (0.22, 0.39 and 0.43), (0.34, 0.37 and not detection), (0.66, 0.32 and 0.38) and (56.37, 37.20 and 38.40) mg|kg respectively.

The results of this study showed, there was no significant difference between type of sausage beef, goat and camel meat with the level of lead, cadmium, mercury and arsenic, however the concentration of beef, goat and camel sausage was lower than detection limits. Also the result showed, there was high significant difference ($p \leq 0.01$) in chromium, copper and iron between type of sausage and no significant difference between type of sausage in manganese, zinc and nickel. The results showed the concentration of essential metals; Cr, Cu, Mn, Zn, Ni, and Fe in beef, goat and camel sausage as (0.6, 0.27 and 0.36), (1.07, 0.5and 0.02), (0.33, at detection limits and 0.04), (0.72, 0.31 and 0.16), (0.01, 0.01 and 0.01) and (76.14, 38.32 and 37.81) mg|kg respectively.

There was no significant difference between samples of fresh meat and sausage in lead, cadmium, mercury and arsenic. The concentration of lead, cadmium, mercury and arsenic in fresh and sausage of beef, goat and camel sausage was lower than detection limits. There was high significant difference ($P \leq 0.05$) between fresh meat and sausage samples in Iron chromium and copper, but no significant different (NS) in nickel, manganese and zinc.

The result showed that, All the samples were conformed with some international standards; FAO (2003), European Commission (EC 1881, 2006), Food Standards Australia New Zealand (FSANZ, 2015), China standard (2006) and gulf standards (2015).

## ملخص الدراسة

أجريت هذه الدراسة في كلية علوم وتكنولوجيا الإنتاج الحيواني - جامعة السودان للعلوم والتكنولوجيا. خلال الفترة من فبراير (2016) إلى مايو (2017) للتحقيق في تركيز الرصاص والكادميوم والزئبق والزرنيخ والنيكل والكروم ، الزنك والمنغنيز والنحاس والحديد في اللحوم الطازجة وسجك لحم الابقار والماعز والإبل ، ومطابقة لبعض المعايير الدولية. تم جمع العينات من بعض الأسواق العامة بولاية الخرطوم وتصنيعها في مختبر علوم وتكنولوجيا اللحم - كلية علوم وتكنولوجيا الإنتاج الحيواني - جامعة السودان للعلوم والتكنولوجيا. تم التحليل في مختبر معهد بحوث التصحر والموارد الطبيعية.

أوضحت النتائج عدم وجود فرق معنوي بين نوع اللحم الطازج في الرصاص والكادميوم والزئبق والزرنيخ . مستوى الرصاص والكادميوم والزئبق والزرنيخ في اللحم البقري الطازج والماعز ولحوم الإبل أقل من حدود الكشف (0.001) أظهرت النتائج وجود فروق معنوية عالية ($p \leq 0.05$) في الكروم والزنك والنيكل والحديد بين أنواع اللحوم الطازجة, ولا فرق معنوي بين انواع اللحم الطازج في المنغنيز والنحاس. أظهرت النتائج ان تركيز المعادن الأساسية Cr، Mn، Zn، Ni، Cu و Fe في اللحم الطازج البقري والماعز ولحوم الإبل (0.52 ، 0.32 و 0.38) ، (0.08 ، 0.25 واقل حدود الكشف) ، (0.22 ، 0.39 و 0.43) ، (0.34 ، 0.37 وعدم الكشف) ، (0.32،0.66 و 0.38) و (56.37 ، 37.20 و 38.40) ملغم | كجم على التوالي.

أظهرت نتائج هذه الدراسة أنه لا يوجد فرق معنوي بين انواع سجوك لحم البقر والماعز ولحوم الإبل مع مستوى الرصاص والكادميوم والزئبق والزرنيخ ، ولكن تركيز اللحم البقري والماعز وسجوك الجمال كان أقل من حدود الكشف. كما أظهرت النتائج وجود فروق معنوية عالية ($p \leq 0.05$) في الكروم والنحاس والحديد بين انواع سجوك ولا فرق كبير بين انواع السجوك في المنغنيز والزنك والنيكل. أظهرت النتائج ان تركيز المعادن الأساسية. Cr، Cu، Mn، Zn، Ni و fe في سجوك لحم الابقار والماعز والابل كانت ( 0.6, 0.27 and 0.36), (1.07, 0.5and 0.02), (0.33, at detection limits and 0.04), (0.72, 0.31 and 0.16), (0.01, 0.01 and 0.01) and (76.14, 38.32 and 37.81) ملغ\ كغ علي التوالي .

لم يكن هناك فرق كبير بين عينات من اللحوم الطازجة والسجك في الرصاص والكادميوم والزئبق والزرنيخ. وكان تركيز الرصاص والكادميوم والزئبق والزرنيخ في اللحوم الطازجة والسجك البقري والماعز وسجك الابل أقل من حدود الاكشف. كان هناك فرق كبير معنوي ($P \leq 0.05$) بين اللحم الطازج

وعينات السجوك في الكروم والحديد والنحاس ، ولكن لا يوجد اختلاف معنوي (NS) في النيكل والمنغنيز والزنك.

أظهرت النتائج أن جميع العينات كانت مطابقة لبعض المعايير الدولية مثل منظمة الأغذية والزراعة (2003) ، المفوضية الأوروبية ( EC 1881، 2006) ، معايير الأغذية في أستراليا ونيوزيلندا ( FSANZ، 2015) ، الصين (2006) ومعايير دول الخليج (2015).

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## Introduction:

Food safety is a major public concern worldwide. During the last decades, the increasing demand of food safety has stimulated research regarding the risk associated with consumption of food stuffs contaminated by pesticides, heavy metals and/or toxins (Mello, 2003). The implication associated with heavy metal contamination is of great concern. Heavy metals, in general are not biodegradable, having long biological half-lives and having the potential for accumulation in the different body organs leading to unwanted side effects (Jarup ,2003; Sathawara *et al* .,2004). These metals can pose a significant health risk to humans, particularly in elevated concentrations above the very low body requirements (Reem *et al.,* 2012).

Applying food safety standards on a food product is very important because it relates closely to human's health. Good food products have a high nutritional quality, as well as being free from physical, chemical and biological contaminations. The food industry development encourages food manufacturer's to produce more practical and durable products, but still must have high nutrition. For example, beef processing to produce meatballs, corned beef, beef burgers and sausages have the purpose to form more practical and durable products, as well as having high nutritional value(Farmer and Farmer, 2000; Javed *et al.,* 2009.).

Meat is a very important human food; therefore, it may potentially accumulate toxic minerals and represents one of the sources of heavy metals for humans (Bendeddouche *et al.,* 2014). Meat is very rich and convenient source of nutrients including also a large extent of microelements. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Anetta Lukáčová *et al.*, 2014).

Heavy metals are persistent as contaminations in the environment and come to the forefront of dangerous substances causing healthy hazard in human. Lead, cadmium, mercury and tin are among the most important of these elements. Industrial and agricultural processes have resulted in an increased concentration of heavy metals in air, water, soil and subsequently, these metals are taken by plants or animals and take their ways into food chain (Ahmed, 2002). The presence of heavy metals in animal product may be attributed to contamination of the original animal, which may be due to exposure of lactating and environmental pollution or consumption of contaminated feeding stuffs and water (Carl, 1991 and Okada *et al*., 1997).

Heavy metals are dangerous because they tend to accumulate in living organisms. Some heavy metals are deposited as residues in food, during processing (WHO, 2000). Chronic exposure to these products leads, on long term, to undesirable effects for consumers' health and organic resistance. Normally, the exposure is kept at low, controlled level, due to quality standards imposed for water and feed (EC 178, 2002).

Contamination of animal product with heavy metals may cause a serious risk for human health because of the consumption of even small amount of metals can lead to considerable concentrations in human body, metals that cannot metabolized as cadmium; lead and mercury persist in the body and exert their toxic effect by combination with one or more reactive groups essential for normal physiological function and cellular disturbances or clinical manifestation may be appear (Abdalla, 2012)

Technological process of meat processing can create a potential source of heavy metals in final products. Improvements in the food production and processing technology are increasing the chances of food contamination with various environmental pollutants, especially heavy metals (Anetta *et al*,, 2014).

**Overall objective:**

1. To study the safety of fresh meat and sausage of beef, goat and camel from heavy metals in Khartoum State.

**Specific objectives**:

1. To study quality and safety of fresh meat and sausage.
2. To identify possible toxicants present in beef, camel and goat sausage.
3. To quantitatively measure the Lead, Cadmium, Mercury, Arsine, Zinc, Nickel, Manganese, Iron, Copper, and Chromium in the fresh meat and sausage of beef, goat and camel.
4. To compare the toxicant to their allowed limits according to some international standards.

# hapter Two

# Literature Review

## 2.1: Meat:

Meat is defined as those animal tissues, which are suitable for use as food. All processed or manufactured products, which might be prepared from those tissues, are included in the definition (Judge et al, 1990). Gunter and Peter (2007) defined meat as “the muscle tissue of slaughter animals”.

### 2.1.1: The nutritive value of meat:

The nutritive value of meat is attributed to it is protein, fat, carbohydrates, vitamins and minerals content (Mahassin, 2008). Red meat contains protein of high biological value and important micronutrients that are needed for good health throughout life. It also contains a range of fats, including essential omega-3 polyunsaturated fats. Although the nutritional composition of meat vary somewhat according to breed, feeding, season and meat cut, In general lean meat has a low fat content, moderate in cholesterol and rich in protein and many essential vitamins and minerals (Williams, 2007).

Meat is essential for growth and maintenance of good health and mainly composed of proteins, fat, carbohydrate and some important essential elements. Need for mineral compounds depend on age, physiological state and feed intake as well as on living conditions (Ayesha *et al*, 2014). Meat makes up an essential part of the food and is mainly composed of protein, fat and some important essential elements (Akan *et al*. 2010). It is also a good source of niacin, vitamins B6 and B12, phosphorous, zinc, and iron (Williams, 2007). Animal proteins have a high biological value (Ziegler, 1968), and the presence of essential amino acids it a cumplete protein (Bastin 2007). Apart from meat and meat products forming an important part of the human diet as well as an important source of a wide range of nutrients, they may also carry certain toxic substances (Fathy *et al.* 2011).

## 2.2: Sausage:

The process of preserving meat by stuffing salted, chopped meat flavored with spices into animal casings dates back thousands of years, to the ancient Greeks and Romans, and earlier(AFDO, 1999).It is difficult to define sausage in single definition due to the variety of different type. Sausage can be defined as comminuted processed meat product made from red meat, poultry or combination of these with water, binder and seasoning (Essien, 2003). The term sausage is derived from the Latin word (salsus) meaning salt, or literally translated refers to chopped or minced meat preserved by salting and seasoned (Pearson and Tauber, 1984). Jihad *et al* (2009) define Sausage as prepared food, usually made of ground meat animal fat, salt, spices (sometimes with other ingredient such as herbs) and typically packed in a casing.

### 2.2.1: Sausage ingredient:

#### 2.2.1.1: Meat:

The finished product is only as good as the ingredients it contains. Meat should be fresh of high quality, have the proper lean-to-fat ratio and have good binding qualities. The meat should be clean and not contaminated with bacteria or other microorganisms. In other words, meat used in sausage production should be safe (Martin, 2012). Fresh and high quality meat such as lamb, beef, pork, mutton, poultry, veal and wild game may be used in sausage production. Less costly cuts such as round cuts, beef short ribs, pork shoulders or chuck cuts may be used. Cuts from the head and leftover trimmings from slaughter can also be used in sausage (Roxie, 2010). The characteristics of the meat ingredients used to create the sausage, define the type of sausage - the overall taste, texture, aroma, along with the protein and fat content (AFDO, 1999).

### 2.2.1.2: Fat:

Fat content of meat used for comminuted meat products is influenced primarily by carcass grade and particular cut or type of trimming from the carcass. Variations in fat content greatly exceed those of moisture and protein. If moisture and protein are known, fat content may be approximated by difference, allowing about 0.8% for ash (Pearson and Tauber, 1984). Isidor *et al.* (1972) reported that in fresh or smoked sausage fat may reach about 20% in semi-dry or dry beef sausage, like frankfurters, the fat is part of an emulsion system participating in the formation of characteristic structure of product.

### 2.2.1.3: Salt

Salt plays a significant function in the processes of digestion and essential element in the diet of humans, animals and plants. Salt is one the mostly used food additive with unique place in food consumption. Salt (sodium chloride) is an essential additive which routinely added to majorities of foods not only for improving taste but also as a preservative to many canned, salted and pickled or fresh foods. Salt brings out natural flavors and makes food acceptable, protects food safety by retarding the growth of spoilage microorganisms, gives proper texture to processed foods, serves as a control agent to regulate the rate of fermentation in food processing, strengthens gluten in bread, provides color, aroma and appearance consumers expect and is used to create the gel necessary to process meat and sausages (Cheraghali *et al*., 2010; AL-Rajhi, 2014)

Salt is an ingredient that is always used in sausage products. Technically, it is the only non-meat substance required for a product to be considered a sausage. Salt serves three functions in the meat. It lowers the amount of available water (which allows for preservation or shelf-life extension), extracts the meat myofibrillar proteins needed to make the product bind and to emulsify fat, and for flavor enhancement (wafaa, 2014). In addition to taste, salt has the ability to extract some proteins from meat. As the sausage is heated, the protein matrix coagulates, the meat particles bind together and the texture of the sausage becomes firm. Salt also enhances flavor, reduces microbial spoilage, and increases water absorption and retention (Judge *et al*., 2001; Kerry *et al*., 2002).

### 2.2.1.4: Spices:

Depending on the variety of sausage, various types and amounts of spices and herbs may be used to add flavor to the product. Black pepper, white pepper, paprika, sage, garlic, cumin, fennel, oregano and many other seasonings are used to improve appearance and add flavor to sausages. Seasonings influence the flavor, appearance or shelf life of the product; Seasonings are classified further as spices, herbs, aromatic vegetables, flavoring enhancers and stimulated meat flavors. Certain spices such as black pepper .ginger and mace have antioxidant properties and will help extend the shelf life of sausage (Pearson and Gillett, 1996, (Wafaa, 2014).

Al-Eed *et al*. (1997) pointed on the addition of spices that may be contaminated with trace and heavy metals to food as a habit may result in accumulation of these metals in human organs and can cause different health problems. Nkansah and Amoako (2010) warned that process of spices preparation and handling can make them a source of food poisoning. Larkin et al. (1954) reported that pepper contains higher levels of lead (>2.5 ppm) as is added invariably to almost all types of meat products. Nkansah and Amoako (2010) reported that high value of Pb was registered for black and white pepper (0.965 and 0.978 mgkg-1, respectively). Ozkutlu *et al.*, (2006) reported highest concentration of lead in the samples of garlic (0.999 mgkg-1).

### 2.2.1.5: Culd water or ice (Water added):

Water and ice are added to provide moisture and keep the sausage cold. Cold temperature delays microbial growth and also ensures a better final product texture. Ice and water can also be added to increase the yield of sausage, but there are upper limits for wholesale or retail marketing. Water also aids in dissolving salt to facilitate its distribution within the meat. Texture and tenderness of the finished sausages are markedly affected by added water content (Pearson and Gillet, 1996, Sabahu , 2016). SSMO (2008) reported the level of added water in fresh sausage should not exceed 10%. The water added in fresh sausage up to 3% of total product weight (AFDO, 1999).

### 2.2.1.6: Casing:

Casings are soft cylindrical containers used to contain sausage mixes. Casings can be of natural origin or artificial. Natural casings are obtained from animal intestines. Artificial casings are made of cellulose, collagen or synthetic materials. Sausage fillings are mostly minced or comminuted meat mixes held together by the casings during further processing steps such as smoking, boiling, frying or roasting. In addition, casings also protect products during storage (FAO, 2010).

### 2.2.1.7: Extra ingredient: Additive:

Food additives are used to accomplish certain functions such as coloring, antimicrobial, antioxidant, preservation, improved nutrition, increased emulsification and altered flavor (Okerman,1986; Jihad, 2009).The use of food additives has become more prominent in recent years due to the increased production of prepared, processed and convenient foods (Directive No 95/2/EC, 2006).

Additives can be included in sausage products but under strict conditions and legal limits. They are used to impact the color, minimize rancidity or to inhibit microbial growth. Examples of these are sodium nitrite, phosphates, sodium ascorbate, and sodium erythorbate (Knipe, 2003).

### 2.2.1.8: Binders and Extenders.

Binders used in meat processing technology divided into two groups: **first** plant proteins such as soy isolates, soy concentrates and flours, **second** protein of animal origin such as milk protein (Meltem and Meltem, 2003). A sausage formulation can include up to 3.5 of binder and extender (AFDO, 1999).

### 2.2.3: Manufacturing sausage:

Sausage making and manufacturing is a continuous sequence of events. Each step in proper sequence is important to successful operation in studying sausage processing; it is convenient to separate the process into four basic processing: selecting ingredient, grinding, mixing and thermal processing (Pearson and Gillett, 1996).

## 2.3: Heavy Metals:

Metals in general can be classified as toxic (cadmium, lead and mercury) and essential (cobalt, copper, zinc, iron). Toxic elements can be very harmful even at low concentration when ingested over a long time period due to their ability to accumulate in human and animal body (Ray, 1994). A heavy metal is defined as a metal, which is neither essential nor has beneficial effect, on the contrary, it displays severe toxicological symptoms at low levels and is defined as a metal with a specific weight more than 5 g/cm3(Gonzales-Waller et al., 2006).Of the 92 naturally occurring elements, approximately 30 metals and metalloids are potentially toxic to humans, Be, B, Li, Al, Ti, V, Cr, Mn, Cu, Ni, Cu, As, Se, Sr, Mo, Pd, Ag, Cd, Sn, Sb, Te, Cs, Ba, W, Pt, Au, Hg, Pb, and Bi. Heavy metal is the generic term for metallic elements having an atomic weight higher than 40.04 (Ming-Ho, 2005). The sources of toxic metals in the environment are the fossil fuels, mining industries, waste disposals and municipal sewage. Farming and forestry also cuntribute to the metal content in the environment due to the uses of fertilizer, pesticide and herbicides (Jayasekara *et al.,* 1992; Lukáčová and Golian, 2014).

### 2.3.1: Source heavy of metals:

Heavy metals enter the environment by natural and anthropogenic means. Such sources include: natural weathering of the earth’s crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents, pest or disease control agents applied to plants, air pollution fallout, and a number of others (Ming-Ho, 2005).

Metals occur naturally in the earth's crust, and their contents in the environment can vary between different regions resulting in spatial variations of background concentrations. The distribution of metals in the environment is governed by the properties of the metal and influences of environmental factors (Khlifi and Hamza, 2010; Monisha *et al.,* 2014).

Heavy metals from manmade pollution sources are continuously released into aquatic and terrestrial ecosystems and therefore the concern about the effect of anthropogenic pollution on the ecosystems is growing. Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Demirezen and Uruc, 2006). Absorption of metals and metal compounds inhaled as particles are influenced by several processes that include deposition, mucuciliary and alveolar clearance, solubilization and chemical binding (André *et al.*, 2005). Instances of heavy metal contamination in meat products during processing have also been reported (Akan *et al.* 2010; Harlia and Balia 2010). Methods such as singeing off the hairs of the animals in flame fuelled by various substances such as wood mixed with spent engine oil, plastics mixed with refuse or tyres. These materials contain toxic substances such as heavy metals which can contaminate the meat and render them unfit for human consumption (Okiei *et al*. 2009).

### 2.3.2:Risk of heavy metals:

After entering the body, the metals deposited in nasopharygeal, tracheobronchial, or pulmonary compartments may be transported by mucuciliary action to the gastrointestinal tract. Metals can also be phagocyted by macrophages (André *et al*., 2005).

The risk of heavy metal 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 (Santhi *et al*., 2008).

Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain. These pollutants often have direct physiological toxic effects because they are stored or incorporated in tissues, sometimes permanently (Marian and Jonathan, 2014). Heavy metals such as mercury, plutonium, and lead are toxic metals that have no known vital or beneficial effect on organism and their accumulation over time in the bodies of animals and humans can cause serious ailments. Among all heavy metals, however, cadmium and lead are known as highly toxic (Reena *et al.*, 2011). The toxicity of heavy metals depends on a number of factors. Specific symptomatology varies according to the metal in question, the total dose absorbed, and whether the exposure was acute or chronic. The age of the person can also influence toxicity. For example, young 2 children are more susceptible to the effects of lead exposure because they absorb several times the percent ingested compared with adults and because their brains are more plastic such that even brief exposures may influence developmental processes (Soghonian and Sinert, 2008).

Lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As) are widely dispersed in the environment. These elements have no beneficial effects in humans, and there is no known homeostasis mechanism for them (Draghici *et al.*, 2010; Vieira *et al.,* 2011). They are generally considered the most toxic to humans and animals; the adverse human health effects associated with exposure to them, even at low concentrations, are diverse and include, but are not limited to, neurotoxin and carcinogenic actions (ATSDR, 2003a, 2003b, 2007, 2008).

### 2.3.3: Element of heavy metals:

#### 2.3.3.1: Lead (pb):

Lead as a toxicologically relevant element has been brought into the environment by man in extreme amounts, despite its low geochemical mobility and has been distributed worldwide (Oehlenschläger, 2002). Lead still has a number of important uses in the present day; from sheets for roofing to screens for X rays and radioactive emissions. Like many other contaminations, lead is ubiquitous and canbe found occurring as metallic lead, inorganic ions and salts (Harrison, 2001).

Lead is a toxic metal that has no known vital or beneficial effect on organisms and its accumulation over time in the bodies of animals and humans can cause serious ailments. lead may enter the atmosphere during mining, smelting, refining, manufacturing processes and by the use of lead containing products ((Marian and Jonathan, 2014).

##### 2.3.3.1:1: Source of lead:

The source of lead contamination of livestock come from the air, water they drink and food they eat. In general, lead accumulates in the plants and animals, while its concentration is magnified in the food chain (Halliwell *et al.*, 2000). Food is one of the major sources of lead exposure; the others are air (mainly lead dust originating from petrol) and drinking water. Plant food may be contaminated with lead through its uptake from ambient air and soil; animals may then ingest the lead contaminated vegetation. In humans, lead ingestion may arise from eating lead contaminated vegetation or animal foods. Another source of ingestion is through the use of lead-containing vessels or lead-based pottery glazes (Ming-Ho, 2005).

### 2.3.3.1.2: Toxicity of lead:

Lead is a metabolic poison and a neurotoxin that binds to essential enzymes and several other cellular components and inactivates them (Cunningham and Saigo, 1997). Toxic effects of lead are seen on haemopoietic, nervous, gastrointestinal and renal systems (Baykov *et al.,* 1996). Lead has no essential function in humans, about 20 to 50% of inhaled, and 5 to 15% of ingested inorganic lead is absorbed. In contrast, about 80% of inhaled organic lead is absorbed, and ingested organic Pb is absorbed readily. Once in the bloodstream, lead is primarily distributed among blood, soft tissue, and mineralizing tissue (Ming-Ho, 2005). The bones and teeth of adults contain more than 95% of the total body burden of lead. Children are particularly sensitive to this metal because of their more rapid growth rate and metabolism, with critical effects in the developing nervous system (ATSDR, 2007; Castro-González and Méndez-Armenta, 2008).

Lead is toxic heavy metal with widespread industrial use, but no known nutritional benefits. Chronic exposure at relatively low levels can result to damage to kidneys and liver and to immune, reproductive, cardiovascular, nervous and gastrointestinal systems (Okoye and Ugwu, 2010). Lead, for example, bio-accumulates in plants and animals. Its concentration is generally magnified in the food chain (Halliwel *et al.*, 2000). Tuormaa (1995) reported that an excessive lead accumulation in children is known to cause hyperactivity, reduced intelligence and antisocial behavior. Lead could cause adverse effects on the renal and nervous systems and cross the placental barrier, having potential toxic effects on the fetus (WHO, 2003). The main toxic effect of lead is nervous system dysfunction of the fetus and infants. In adults, it causes adverse blood effects, reproductive dysfunctions, damage to the gastrointestinal tract, nephropathies, damage to the central as well as the peripheral nervous system and interferences in the enzymatic systems (Rubio *et al.,* 2005). Janefrances (2010) reported that, the lead intoxication leads as: Encephalopathy in the central nervous system, Disturbances in the kidney and liver functions progressing as far as necrosis, Damage to the reproductive organs, premature births, spontaneous abortion, Anemia and many metabolic deficiency symptoms.

### 2.3.3.1.3: Lead in meat and sausage:

The Joint FAO/ World Health Organization Expert Committee on Food Additives (JECFA) established a provisional tolerable weekly intake (PTWI) for lead as 0.025 mg/kg body weight (bw) (JECFA, 2004). Overexposure to lead affects the neurological, reproductive, renal, haematological systems. Studies show that children are more prone to lead toxicity as compared to adults (Gonzalez - Waller *et al.* 2006). Lukáčová and Golian (2014) found the lead in beef meat from 0.0191 to 0.090ppm. Oskarsson *et al.* (1992) reporting lead concentration in the range of 0.412- 0.568 ppm in beef. All the meat analysed contain lead in high doses (above the tolerable limit), and this could be due to the use of lead containing products during meat processing. Higher levels of lead in beef could be as a result of the areas in which cattle were reared (Harlia and Balia 2010). Bendeddouche *et al.* (2014) stated that the average amount of this metal was between 7.76-8.43 ppm of beef slaughtered in Algeria. Akan *et al,* (2010) who determined lead concentrations in beef as (0.25 ppm). Demirezen and Uruc (2006), who corresponding values for lead in meat (0.18-0.28 ppm).

Muller and Anke (1995) reported that lead content in sausage was higher than that in the meat used for its production, presumably due to the spices used in sausage production. Nkansah and Amoako (2010) reported that high value of Pb was registered for black and white pepper (0.965 and 0.978 mg.kg-1) respectively. Gonzales-Waller *et al.* (2006) who reported the mean concentration of lead in the pork meat products samples 6.72 ppb and in the beef products samples 9.12 ppb. Demirezen and Uruc (2006) reported that the highest average lead concentrations were obtained from pastirma, meat and sausage (0.126, 0.115, 0.135 ppb) respectively.

Anetta *et al.,* (2014) found increasing concentration of lead after the addition of additives, spices and curing compounds causing a threefold increase in the concentration of lead in final products in meat. However there is an absolute need for good manufacturing practices - Hazard Analysis and Critical Control points to monitor and curtail the contaminations in meat and meat products. Al-Eed *et al.* (1997) pointed on the addition of spices that may be contaminated with trace and heavy metals to food as a habit may result in accumulation of these metals in human organs and can cause different health problems. Nkansah and Amoako (2010) warned that, process of spices preparation and handling can make them a source of food poisoning. Lead may reach and contaminate plants, vegetables and fruits. Monitoring of the levels of heavy metals in spices would help ascertain the health impact of taking spices. Ozkutlu *et al.,* (2006) reported the high concentration of lead in the garlic (0.999 mg|kg$^{-1}$)

Lukáčová *et al.,* (2014) reported, the concentration of lead in beef as (0.142) ppm. Also Rab Nawaz *et al,.* (2015) found the lead in beef as (0.7 - 6.75) ppm. However, Marain and Jonathan (2014) found the lead level in beef as (1.154) ppm. Oskarsson *et al.* (1992) reported a high lead concentration as (500 µg/kg-1) in beef comparative other meat. In the other study Amani and Lamia (2012) reported that, the level of lead in beef and goat and camel meat as (7.61), (6.35) and (5.48) ppm respectively. Also Marian and Jonathan (2014) found the concentration of lead in beef and goat meat as (1.154) and (0.377) ppm respectively. However , Akan *et al* (2010) found , lead concentrations in the meat of beef, mutton, caprine and chicken as range from (0.04 to 0.10) g/g. also Bendeddouche *et al.,* (2014) the concentration of lead in beef , goat and camel meat as (7.76) ,( 3.49) and (2.01)ug\g respectively. And González et al., (2006) found concentrations of lead as (6.94) $\mu g\, kg^{-1}$ in chicken meat, (5.00) $\mu g\, /kg^{-1}$ in pork meat, (1.91) $\mu g/\, kg^{-1}$ in beef meat and (1.35) $\mu g/\, kg^{-1}$ in lamb meat samples. Chafik (2014) reported the concentration of lead in beef, sheep and camel as (0.78, 0.85 and 0.71) ppm respectively

Muller and Anke (1995) reported that lead content in sausage was higher than that in the meat used for its production, presumably due to the spices used in sausage production. Also Demirezen and Uruc (2006) reported that the highest average lead concentrations were obtained from pastirma, meat and sausage (0.126, 0.115, 0.135 ppb, respectively). However, Gonzales-Waller *et al.,* (2006) who reported the mean concentration of lead in the beef products samples 9.12 ppb. In other study Amani and Lamia (2012) found the lead in sausage as (5.43) ppm. Also Gabriel *et al.,* (2014) reported that, the highest concentration of Lead was found in salami (0.96 mg/kg), followed by the concentration in sausage (0.82 mg/kg), Also Abedi 2011 reported that Determination of lead content in sausages from Irapn as 53.5pb. And González et al., (2006) found Concentrations of lead in chicken meat product samples as (3.16) $\mu g/\, kg^{-1}$, pork meat product (4.89) $\mu g\, /kg^{-1}$ in, and (4.76) $\mu g\, /kg^{-1}$ in beef meat product. Santhi *et al.,* (2008) reported relatively higher lead content in bacon as (1.641) ppm, ham (1.966) ppm, sausage (1.352ppm, salami (3.250) ppm and luncheon meat (2.231) ppm obtained from retail outlets of Chennai city. Dora *et al.,* (2014) found trace metals lead in beef and sausage (9.0 and 9.0) ug/kg respectively. Also Amani and Lamia (2012) found the trace element, lead in sausage as 3.24–9.17 μg/g.

### 2.3.3.2: Cadmium (Cd):

#### 2.3.3.2.1: Source of cadmium:

Cadmium is one of the metallic elements of most cuncern in the food and environment of man. The main exposure is encuuntered in industries dealing with pigment, metal plating, some plastics and batteries. Cadmium pollution (e.g. the emissions of a cadmium smelter or industry and the introduction of cadmium into sewage sludge, fertilizers and groundwater) can result insignificant human exposure to cadmium through the ingestion of contaminated foodstuffs, especially grains, cereals, and leafy vegetables (Smolder, 2001; Reesal *et al.,* 1987). Airborne cadmium exposure is also a risk posed by the incineration of municipal waste containing plastics and nickel-cadmium batteries. Cigarette smoking constitutes an additional major source of cadmium exposure (Janference, 2010). 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 in air, drinking water and food has the potential to affect the health of whole populations (WHO, 1994).

Tobacco smoke is one of the largest single sources of cadmium exposure in humans. Tobacco in all of its forms contains appreciable amounts of the metal. Because the absorption of cadmium from the lungs is much greater than from the gastrointestinal tract, smoking contributes significantly to the total body burden (Figueroa, 2008; Ming-Ho, 2005).

In general, for non-smokers and non-occupationally exposed workers, food products account for most of the human exposure burden to cadmium (ExtoxNet, 2003). In food, only inorganic cadmium salts are present. Organic cadmium compounds are very unstable. In contrast to lead and mercury ions, cadmium ions are readily absorbed by plants. They are equally distributed over the plant. Cadmium is taken up through the roots of plants to edible leaves, fruits and seeds. During the growth of grains such as wheat and rice, cadmium taken from the soil is concentrated in the cure of the kernel. Cadmium also accumulates in animal milk and fatty tissues (Figueroa, 2008). Therefore, people are exposed to cadmium when consuming plant- and animal-based foods. Seafood, such as molluscs and crustaceans, can be also a source of cadmium (Castro and Méndez, 2008; WHO 2004b; WHO 2006). Food is one of the principle environmental sources of cadmium (Baykov *et al.*, 1996). As cadmium moves through the food chain it becumes more and more concentrated as it reaches the carnivores where it increases in concentration by a factor of approximately, 50 to 60 times (Daniel and Edward, 1995).

### 2.3.3.2.2: Toxic of heavy cadmium:

Cadmium is not known to have any beneficial effects, but can cause a broad spectrum of toxicological and biochemical dysfunctions (Funakoshi et al., 1995). Cadmium is a cumulative toxicant in the continental ecological cycling; it accumulates mostly in the liver and kidney (Zasadowski *et al.*, 1999)

The use of cadmium by man is relatively recent and it is only with its increasing technological use in the last few decades that serious cunsideration has been given to cadmium as a possible cuntaminant.

Cadmium is naturally present in the environment: in air, soils, sediments Sand even in unpolluted seawater. Cadmium is emitted to air by mines, metal smelters and industries using cadmium cumpounds for alloys, batteries, pigments and in plastics, although many cuuntries have stringent controls in place on such emissions (Harrison, 2001).

The renal toxicity of cadmium is reduced or abolished by increasing intakes of zinc, copper and selenium. The preventive effects of pretreatment with zinc and copper have been suggested to be the result of increased production of metallothione in the liver and renal curtex (Pizent *et al.,* 2001).Cadmium accumulates in the human body affecting negatively several organs: liver, kidney, lung, bones, placenta, brain and the central nervous system (Castro and Méndez, 2008). Other damages that have been observed include reproductive, and development toxicity, hepatic, haematological and immunological effects (Apostoli and Catalani, 2011; ATSDR, 2008). Toxic effects of cadmium are kidney dysfunction, hypertension, hepatic injury and lung damage (John and Jeanne, 1994). Cadmium chloride at teratogenic dose induced significant alterations in the detoxification enzymes in the liver and the kidney (Reddy and Yellamma, 1996) The health risks caused by lead and cadmium are well known and the levels in food as well as the migration of these metals from food containers are regulated (Tahvonen and Kumpulainen, 1994).

Cadmium has a long eminence in the human body (between 10-40 years), especially in the kidneys (Rubio et al., 2006). In some cases, high concentrations of Cu and Zn in feeds for pigs and poultry lead to contamination of produced manure. If this is applied to agricultural land, as fertilizer, it might lead to pollution of land with these metals resulting in a pollution risk for other animals that are fed with the plants issued from that field (Poulsen, 1998). The biological half life of Cadmium in the human kidney is long and has been estimated to be 10 to 30 years (Fox Spivey, 1987; Gabriel 2014)

The risk associated with the exposure to heavy metals present in food product has aroused widespread concern in human health. Cadmium is primarily toxic to kidney, especially to proximal tubular cells. Bone demineralization is affected by cadmium toxicity directly by bone damage and indirectly as results of renal dysfunction (Marian and Jonatha, 2014)

### 2.3.3.2.3: Cadmium in meat and sausage:

The limit of cadmium in meat as 0.5 mg/kg, as recorded by USDA, (2006). The Joint FAO/WHO Expert Committee on Food Additives (JECFA, 2004) has recommended the Provisional tolerable weekly intake (PTWI) as 0.007 mg/kg blew for cadmium. The EPA maximum contaminant level for cadmium in drinking water is 0.005 mg/L whereas the WHO adopted the provisional guideline of 0.003 mg/L (WHO, 2004a). The concentration of cadmium in beef and chevon as (0.079) and (0.018) ppm respectively (Marian and Jonathan, 2014). Also Rab Nawaz *et al.,* (2015) found the concentration of cadmium in beef as (0.01 - 0.93) ppm. However, Amani and Lamia (2012) reported that, the cadmium in beef and goat and camel meat as (1.68), (1.25) and (1.07) ppm respectively. In other study by Akan *et al.,* (2010) found, cadmium concentrations in the meat of beef, mutton, caprine and chicken as range from 0.070 to 0.29 mg/g. Also Bendeddouche *et al*., (2014) ascertained the concentration of cadmium in beef, goat and camel meat as (1.65), (1.93) and (0.91)ug\g respectively. And González et al., (2006) found concentration of cadmium (1.68) µg kg−1 in chicken meat, (5.49) µg kg$^{-1}$

in pork meat, (1.90) μg kg$^{-1}$ in beef meat and (1.22) μg kg$^{-1}$ in lamb meat samples. Also Chafik (2014) reported the concentration cadmium in beef, sheep and camel as (0, 0 and 0.12) ppm respectively

Muller *et al.,* (1992) reported that sausages had higher Cadmium content than the raw meat. The addition of spices during production of sausages might be the main reason since spices could contain cadmium concentrations up to 200 mg/g$^{-1}$. Also Amani and Lamia (2012) reported that, the cadmium in sausage as (3.33) ppm. Abedi (2011) reported Determination cadmium content in sausages from Iran as 5.7cd μg kg$^{-1}$. And González et al., (2006) found Concentrations of cadmium in chicken meat product samples were (4.15) μg kg$^{-1}$, pork meat production as (6.50) μg kg$^{-1}$ and (4.76) μg kg$^{-1}$ in beef meat product. Dora *et al.,* (2014) found the trace metals cadmium in beef and sausage (0.4 and 1.9) ug/kg respectively. Also Amani and Lamia (2012) the concentration of cadmium in sausage as (1.17–4.25) μg/g

#### 2.3.3.3..Mercury

Mercury is one of the most toxic heavy metals in the environment (Castro and Méndez, 2008).

##### 2.3.3.3.1. Source of mercury

Mercury occurs in two forms: organic mercury and inorganic mercury. Inorganic mercury is used in thermometers, barometers, dental fillings, batteries, electrical wirings and switches, fluorescent light bulbs, pesticides, fungicides, vaccines, paint, skin lightening creams, antiseptic creams, pharmaceutical drugs and ointments. The organic form especially methyl mercury is biosynthesized from inorganic mercury as a cunsequence of microbial activity (ASTDR, 1997). Mercury can be detected in most foods and beverages, at levels of < 1 to 50 μg/kg (Reilly, 2007). Higher levels are often found in marine foods. Organic mercury compounds easily pass across biomembranes and are lipophilic. Therefore elevated mercury concentrations are mainly found in liver of lean species and in fatty fish species. Methyl mercury has a tendency to accumulate with fish age and with increasing trophic level. This leads to higher mercury concentrations in old fatty predatory species like tuna, halibut, redfish, shark, and swordfish (Oehlenschläger, 2002). Man released mercury into the environment by the actions of the agriculture industry (fungicides, seed preservatives), by pharmaceuticals, as pulp and paper preservatives, catalysts in organic syntheses, in thermometers and batteries, in amalgams and in chlorine and caustic soda production (Oehlenschläger, 2002; Zhang and Wong, 2007).

### 2.3.3.3.2. Toxicity mercury:

High levels of mercury exposure that occur through, for example, inhalation of mercury vapors generated by thermal volatilization can lead to life threatening injuries to the lungs and neurologic system. Lower but more chronic levels of exposure can lead to erythrism which is characterized by tremor in hands, excitability, memory loss, insomnia, timidity, and sometimes delirium. This was seen in workers exposed to mercury in the felt-hat industry (mad as a hatter) (Hu, 2002). Relatively modest levels of occupational mercury exposure, as experienced, for example by dentist, have been associated with measurable declines in performance on neurobehavioural tests of motor speed, visual scanning, verbal and visual memory and visuomotor cu-ordination (Bittner et al., 1998). Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus (ATSDR, 2003b). The toxicity of mercury depends on its chemical form (ionic < metallic <organic) (Clarkson,

2006). Up to 90% of most organic mercury compounds are absorbed from food (Reilly, 2007).

In the year 2003, the JECFA revised its risk assessment on methyl mercury in fish and adopted a lower PTWI of 1.6 μg/kg body weight/week to replace the previous PTWI of 3.3 μg/kg b.w./week of total mercury for the general population (Castro-González and Méndez-Armenta, 2008; JECFA, 2004). Elemental mercury is relatively inert in the gastrointestinal tract and also poorly absorbed through intact skin, yet inhaled or injected elemental mercury may have disastrous effects (Soghonian and Sinert, 2008).

This risk assessment was based on two major epidemiology studies which investigated the relationship between maternal exposure to mercury through high consumption of contaminated fish and seafood and impaired neurodevelopment in their children (Castro-González and Méndez-Armenta, 2008). Because of the extreme health effects associated with mercury exposure, the current standards for drinking water were set by EPA and WHO at the very low levels of 0.002 mg/L and 0.001 mg/L, respectively (WHO,2004a).

#### 2.3.3.3.1. Mercury in meat and sausage:

The level of mercury in beef and chevon meat as (0.052) and (0.034) ppm respectively (Marain and Jonathan, 2014). Amani and Lamia (2012) reported, the mercury in beef and goat and camel meat as (0.054), (0.023) and (0.039) ppm respectively. However, Bendeddouche *et al.*, (2014) found the concentration of Mercury in beef, goat and camel meat as (0.051), (0.027) and (0.032)ug\g respectively.

The level of mercury in beef and sausage (0.713 and 1.053) ug/kg respectively (Dora *et al.*, 2014). Also Amani and Lamia (2012) found the trace element mercury in sausage (0.014–0.055) µg/g. Hwang *et al.,* (2011) found the mercury in sausage as (01.052) mg/kg.

### 2.3.3.4. Arsenic (As):

Arsenic is a metalloid. It is rarely found as a free element in the natural environment, but more commonly as a component of sulphur-containing ores in which it occurs as metal arsenides (Sawyer *et al.,* 2003).

### 2.3.3.4.1Source of Arsenic:

Arsenic is quite widely distributed in natural waters and is often associated with geological sources, but in some locations anthropogenic inputs, such as the use of arsenical insecticides and the combustion of fossil fuels, can be extremely important additional sources. Arsenic occurs in natural waters in oxidation states III and V, in the form of arsenous acid (H3AsO3) and its salts, and arsenic acid (H3AsO5) and its salts, respectively (Sawyer *et al.,* 2003). The adverse effects of arsenic in groundwater used for irrigation water on crops and aquatic ecosystems are also of major concern. The fate of arsenic in agricultural soils is less characterized compared to groundwater. However, the accumulation of arsenic in rice field soils and its introduction into the food chain through uptake by the rice plant is of major concern mainly in Asian countries (Bhattacharya *et al*., 2007; Duxbury *et al.,* 2003).In some areas of the world, arsenic is also a natural contaminant of wells. Deep-water wells in parts of Taiwan and Chile are now well-known to be contaminated with arsenic, giving rise to chronic manifestation of toxicity (Tsai et al., 1999).

In foods, the major source of arsenic is mainly fish and seafood. The organic arsenic in food and seafood appears to be much less toxic than the inorganic forms (Uneyama *et al.,* 2007). The presence of arsenic in fish has been detected in several species such as; sardine, chub mackerel, horse mackerel (Vieira *et al.,* 2011) blue fish, carp, mullet tuna, and salmon (Castro-González and Méndez-Armenta, 2008). Drinking water is one of the primary routes of exposure of inorganic arsenic (Mudhoo *et al.,* 2011; National Research Council, 2001).

### 2.3.3.4.2: Toxicity of Arsenic:

The greatest threat to public health through arsenic originates from contaminated groundwater. Inorganic arsenic is naturally present at high levels in the groundwater of a number of countries. Drinking-water, crops irrigated with contaminated water and food prepared from contaminated water by these animals might be sources of arsenic exposure (Flanagan *et al.,* 2012). The toxic effects of arsenic depend specially on oxidation state and chemical species, among others. Inorganic arsenic is considered carcinogenic and is related mainly to lung, kidney, bladder, and skin disorders (ATSDR, 2003a). The toxicity of arsenic in its inorganic form has been known for decades under the following forms: acute toxicity, sub chronic toxicity, genetic toxicity, developmental and reproductive toxicity (Chakraborti *et al.,* 2004), immune toxicity , biochemical and cellular toxicity, and chronic toxicity (Mudhoo *et al.,* 2011). Arsenic toxicity and chronic arsenicusis is of an alarming magnitude particularly in South Asia and is a major environmental health disaster (Bhattacharya *et al.,* 2007; Chakraborti *et al.,* 2004). Chronic arsenic ingestion from drinking water has been found to cause carcinogenic and noncarcinogenic health effects in humans (ATSDR, 2003a; Mudhoo et al., 2011; USEPA 2008, 2010a, 2010b). The growing awareness of arsenic-related health problems has led to a rethinking of the acceptable concentration in drinking water (Sawyer *et al.,* 2003). Following a thorough review and in order to maximize health risk reduction, the United States Environmental Protection Agency (USEPA).USEPA in 2001 decided to reduce the drinking water maximum contaminant limit (MCL) to 0.010 mg/L, which is now the same as the WHO guidelines (USEPA, 2005a).Chronic arsenic exposure also causes a markedly elevated risk for developing a number of cancers, most notably skin, cancers of the liver, lung, bladder, and possibly the kidney and colon (Hu, 2002).

#### 2.3.3.4.3 Arsenic in meat and sausage:

The JECFA established a PTWI for inorganic arsenic as 0.015 mg/kg body weight (FAO/WHO, 2005, JECFA 2004). The concentration of arsenic in beef and chevon as (0.007) and (0.012) ppm respectively (Marian and Jonathan (2014). Akan *et al* (2010) found, arsenic concentrations in the meat of beef, mutton, caprine and chicken as range from (0.01 to 0.13) g/g. However, Zahurul *et al* (2011) found the arsenic in beef as (0.18) and goat meat as (0.33) mg/kg.

The levels of arsenic in beef and sausage (16 and18)ug/kg respectively (Dora *et al.,* 2014). Amani and Lamia (2012) found the arsenic in sausage (0.125) mg/kg. Hwang *et al.,* (2011) found the concentration of arsenic (18) mg/kg.

## 2.4: Essential Elements:

Essential elements are very important and necessary for adequate physiological functions of the human body and should be available through dietary intake. These elements are involved in regulation of cellular function, growth and maintenance, and mechanisms of neuromodulation etc (Młyniec *et al.,* 2014). The lack of essential elements in the human diet can cause improper metabolic function and can result in organ damage, chronic diseases and ultimately, death (FAO/WHO, 2000)

### 2.4.1: Nickel (Ni):

### 2.4.1.1: Source of nickel:

Nickel is found in small amount in air, water, soil, and in food (Goyer 1991). Nickel is ubiquitous traces metal and occurs in soils, water, air, and in the biosphere. Most of the nickel is used for production of stainless steel and other nickel alloys with high corrosion and temperature resistance. Nickel alloys and nickel plating are used in vehicles, processing machinery, ornaments, tools, electrical equipments, household appliances and coinage (Janefrances, 2010).

### 2.4.1:2: Toxicity of nickel:

In terms of human health effects, nickel carbonyl is the most acutely toxic nickel compound. The effects of acute nickel carbonyl poisoning include frontal headache, vertigo, nausea, vomiting, insomnia, and irritability, followed by pulmonary symptoms similar to those of an oedema, and cellular derangement. Liver, kidneys, adrenal glands, spleen, brain are also affected. Cases of nickel carbonyl have also been reported in patients dialysed with nickel contaminated dialysate and in electroplaters who accidently ingest water contaminated with nickel sulphate and nickel chloride (WHO, 1991). Soluble nickel compounds are more toxic than insoluble compound (Goyer 1991).when animal or human consumed nickel up to 5g; it may lead to toxicity (Daldrup *et al.*, 1983). Some of the site effect of nickel include: Vomiting, nausea, headache, diarrhea, lung damage and death. The suggested permissible limit for human and animals was 75 µg per day as suggested by Nielsen (1992). Chronic effects, such as rhinitis, sinusitis, nasal sepal perforations, and asthma, have been reported in nickel refinery and nickel plating workers (WHO, 1991). Thus, International Agency for Research on Cancer (IARC) concluded in 1989, that nickel compounds are carcinogenic to humans and metallic nickel is probably carcinogenic to humans (IARC, 1990).

### 2.4.1:2: Nickel in meat and sausage:

Nickel concentrations in the meat of beef, mutton, caprine and chicken as ranged from (0.01 to 0.22) mg/kg(Akan *et al* .,2010). Makanjuola and Olakunle Moses (2016) who found the concentration of nickel in meat as 0.01_0.56 mg/kg. Zahurul *et al.*, (2011) who reported the nickel in beef as (2.64) and goat meat as (0.35) mg/kg. Sathyamoorthy (*et al.*, 2016) who found nickel in meat as (22.1) mg|kg. Also Ijaz *et al*,. (2013) reported concentration of nickel in goat meat as (2.335-13.271) mg|kg.

The levels nickel in meat and meat products as ranged from 8.2_ 24µg/g (Demirezen and Uruç. 2006). Also Sathyamoorthy *et al.*, (2016) found nickel in meat as (22.1) mg|kg

### 2.4.2:.Zinc (Zn):

### 2.4.2.1: Source of zinc:

Zinc is occurs in most foodstuffs and beverages (ATSDR, 1992). The main contributors to zinc intake are meat, especially organ meat, whole grain cereals and milk product including cheese (Cudex, 1995).

### 2.4.2.2: Toxicity of zinc:

Zinc is necessary for the function of a large number of metallo enzymes (ASTDR, 1992). It acts to diminish the toxicity of cadmium and cupper (Florence and Batley, 1980). Zinc may be a modifier of the carcinogenic response; zinc deficiency or excessively high levels of zinc may enhance susceptibility to carcinogens (Bellies, 1994). the acute zinc poisoning have been reported; its manifestations include nausea, vomiting, diarrhea, fever, and lethargy and have been observed, typically, after ingestion of 4-8g of zinc (WHO, 1996). Toxicity of zinc seems to be low; however, various toxic reactions such as the metal fume fever in which the victum suffering from pulmonary distress, fever and gastroenteritis following ingestion of zinc salts have been reported in man (Murphy, 1970, Prasad, 1979). Long-term feeding of very large amounts of zinc salts to rodents resulted in growth retardation, anemia and metabolic effects, and ruminants appear more susceptible to zinc than rodents (Campbell, and Mills, 1979). Underwood (1977) mentioned that zinc does not accumulated with continued exposure, but body content is modulated by homeostatic mechanisms that act principally on absorption and liver levels.

Deficiency of Cupper and Zinc in human nutrition can cause clinical symptoms, while high levels of Lead accumulated in certain organs, such as liver and kidney can generate toxic effects (Cherian and Nordberg, 1983; Gabriel *et al.,* 2014). Zinc is an essential element in animal and human diet. Too little Zinc can cause problems; however, too much Zinc is harmful to human health (nausea and vomiting, epigastric pain, abdominal cramps, and diarrhea) (Plum *et al.,* 2010). Zinc is a common element in the human environment and is essential for many biological functions (Prasad *et al.,* 1963).

### 2.4.2.3: Zinc in meat and sausage:

The Zinc concentration in meat and meat product was below allowed limit of 50 mg/kg (FAO, 2002). Amani and Lamia (2012) reported, the concentration of zinc in beef and goat and camel meat as (41.72), (33.85) and (16.74) ppm respectively. Also Akan *et al* (2010) found, the zinc concentrations in the meat of beef, mutton, caprine and chicken as ranged from (0.10 to 2.04) g/g. Bendeddouche *et al* (2014) the levels of zinc in beef, goat and camel meat as (36.99), (39.64) and (23.51)ug\g respectively. Also Chafik (2014) reported the concentration zinc in beef, sheep and camel meat as 9.04, 6.97 and 9.84ppm respectively. Zahurul *et al* (2011) found the concentrations of zinc in beef (200.20) and goat meat (82.33) mg/kg.

The concentration of zinc in sausage as 65.43 ppm (Amani and Lamia, 2012). Also Dalia and Bassma, (2015) who found Zinc concentration in sausage as (38.59) ppm

### 2.4.3:Chromium (Cr):

Chromium is an essential element helping the body to use sugar, protein and fat, and at the same time carcinogenic for organisms. Excessive amounts may cause adverse health effects (Abd EI-Salam *et al.* 2013)

### 2.4.3.1: Source of chromium:

The main sources of chromium in the diet are cereals, meat, vegetables, unrefined sugar, whale fish, vegetable oil (Cudex, 1995). Chromium cumpounds are also found in pottery, glazes, paper and dyes (Langard and Norseth, 1986).

### 2.4.3.2: Toxicity of chromium:

Chromium (III) is an essential element for normal glucuse metabolism while chromium (VI) is highly toxic (Bellies, 1994; Costa, 1997) due to its high absorption, easy penetration of the cell membranes and its genotoxicity and oxidizing properties (Codex, 1995).

### 2.4.3.3: Chromium in meat and sausage:

According to USDA (2006), the limit of chromium in meat and meat product as 1.0 mg/kg. The concentration of chromium in beef as (1.22) mg/kg and goat meat as (0.08) mg/kg (Zahurul *et al.*, 2011). Marian and Jonathan (2014) found the level of chromium in beef and chevon as (0.304) and (0.632) ppm respectively. Also Akan *et al.*, (2010) found, the concentrations of chromium in the meat of beef, mutton, caprine and chicken as ranged from (0.15 to 0.43) g/g. Marian and Jonathan (2014) found the level of chromium in meat was 0.0472 mg/kg. Abaynch *et al.*, (2011) found the concentration of chromium in meat as (0.073) ppm. Bratakos *et al.*, (2002) found chromium concentration in lamb meat as (0.08–0.16μg/g) and chicken meat as (0.11–0.21μg/g).

The concentrations of chromium in animal meat, organ meat and meat products are in the ranged 0.02_5.36 mg/ $kg^{-1}$, 0.06_0.57 mg/ $kg^{-1}$ and 2.89 _ 4.33 mg/ $kg^{-1}$ respectively (Zahurul *et al.*, 2011).

### 2.4.4: Manganese:

### 2.4.4.1: Source of manganese:

Manganese is ubiquitous in the environment, and human exposure arises from both natural and anthropogenic activities. It occurs naturally in more than 100 minerals with background levels in soil ranging from 40 to 900 mg/kg (Barceloux 1999). Manganese is released to the environment from industrial emissions, fossil fuel combustion, and erosion of manganese- containing soils. Volcanic eruptions can also contribute to levels of manganese in air. Almost 80% of industrial emissions of manganese are attributable to iron and steel production facilities (EPA 2003a). Power plant and coke oven emissions contribute about 20% (EPA 2003a). The general population is exposed to manganese primarily through food intake. The World Health Organization (WHO) estimates that adults consume between 0.7 and 10.9 mg of manganese per day in the diet, with higher intakes for vegetarians who may consume a larger proportion of manganese-rich nuts, grains, and legumes in their diet as compared to non-vegetarians in the general population (WHO 2004b).

#### 2.4.4.2: Toxicity of manganese:

Manganese toxicity represents a serious health hazard in human. Toxic intake of Manganese may result in sever pathological changes particularly in the CNS, neural damage, reproductive and immune system dysfunction, nephritis, testicular damage, pancreatitis and hepatic damage (Keen and Leach, 1987). The toxic action of manganese is exerted on the pulmonary epithelium and cerebral cortex, resulting in degenerative lesions. There are also modifications of the voice, the word and writing, as well as neurovegetative disorders and psychiatric symptoms, irritability, violent behaviour and hallucinations (Villa , *et al.*, 1999).

#### 2.4.4.3: Manganese in meat and sausage:

The concentration of manganese in beef, goat and camel meat as (1.01), (1.01) and (0.88) ppm respectively (Amani and Lamia, 2012). Akan *et al.*, (2010) found, the manganese concentrations in the meat of beef, mutton, caprine and chicken as range from (0.45 to 3.20) g/g. Farooq Ahmad (2016) reported the concentration of manganese in meat as (0.0124 ppm).

The concentration of manganese in sausage as (18.33) ppm (Amani and Lamia, 2012). González *et al.,* (2014) reported the level of manganese in sausage as (0.56) mg|kg. Also disagreed Dalia and Bassma, (2015) reported the manganese concentration in sausage as (8.4)ppm

### 2.4.5.1: Copper (Cu):

Agency for Toxic Substances and Disease Registry ASTDR (2004) reported cupper is an essential component of various enzymes and it plays a key role in bon e formation, skeletal mineralization and in maintaining the integrity of the connective tissues. Cupper acts as a cofactor in various redox enzymes, in mitochondrial respiration, iron absorption, and elastin synthesis. It is also required for the catalytic activities of many metalloenzymes like cytochrome C oxidase, superoxide dismutase, dopamine β-hydroxylase, Lysol oxidase, and tyrosinase (Tapiero *et al.,* 2003, Llanos and Mercer, 2002)

### 2.4.5.2: Toxicity of cupper:

The very high intakes from cupper can cause health problems such as liver and kidney damage, the sheep is more sensitive to cupper toxicity, Determination of the Cu content in food is also an important subject with respect to human consumption (ASTDR, 2004, Lee and Stuebing, 1990). It is a lament toxic to prokaryotic and eukaryotic cells, due to it can bind to proteins and nucleic acids and cause the oxidation of lipids and proteins. Intoxication occurs by intakes voluntary or accidental contamination of drinks. The regulation of the intracellular activity of cupper, as well as the mechanisms that maintain homeostasis of this element, are considered crucial to maintain cell viability and prevent phenomena of toxicity(Florianczy,2003)

### 2.4.5.3: cupper in meat and sausage:

Cupper concentration in red meat as 0.87 mg|kg (González *et al.,* 2014). Bendeddouche *et al.,* (2014) reported the levels of cupper in beef, sheep and camel meat (12.37) (2.56) and (2.82) mg|kg respectively.

The cupper concentration in sausage as (3.45) ppm (Dalia and Bassma, 2015), Amani and Lamia (2012) found the concentration of cupper in sausage as (2.3–12.05) µg/g. Also González *et al.,* (2014) reported cupper concentration in sausage as (1.13)mg|kg.

### 2.4.6.: Iron (Fe):

### 2.4.6.1: Source of iron:

A variation in Fe content was found among different species. However, the Fe content of the same type of meat may vary due to the age of the animal at the time of slaughter, the diet of the animal and husbandry practices (Williamson *et al,.* 2002)

### 2.4.6.2: Toxicity of iron:

Iron deficiency causes anemia and meat is the source of this metal. However when their intake is excessively elevated the essential metal can produce toxic effects (Ponka *et al.,* 2007). The key functions of iron encompass oxygen transport in blood and muscle tissue (through hemoglobin and myoglobin), high intake of iron as well as a high storage in the body has been associated with a wide variety of chronic diseases (Swanson, 2003). Although the problems by an overload of iron in the body’s tissues are less common than the deficiency, these may cause complications such as cirrhosis, liver cancer, diabetes, cardiomyopathy, hypogonadism and arthritis among others. But perhaps the best known and most studied syndrome caused by an excess of iron deposits in the body is the hereditary hemochromatosis recessive disease that causes an increase in the absorption of iron (Burke *et al.,* 2002; Burke *et al.,* 2001).

#### 2.4.6.3: Iron in meat and sausage:

The iron concentration in meat of Beef (84.22) Sheep (70.36) and Camel (75.03) µg/g. (Bendeddouche, *et al*., 2014). *González et al.,* (2014) reported the concentration of iron in red meat as 12.93 mg|kg.

The level of iron in sausage as 12.54 mg|kg (González *et al.*,2014). Dalia and Bassma, (2015) who found iron concentration in sausage as (135) ppm. Also Amani and Lamia (2012) found the levels of iron in sausage as (44.87–250.23) µg/g. Zahran and Hendy (2015) found the concentration of iron in sausage was ranged from 872.9 – 270 mg| kg.

## 2.5: Some international standards:

### 2.5.1: European Commission (EC 1881, 2006):

The maximum levels of heavy metals in meat and meat product lead (0.1), Cadmium (0.05) and Mercury (0.50) mg/kg.

### 2.5.2: FAO (2003):

The maximum levels of heavy metals in meat and meat product Pb (0.5) Cd (0.5) Hg (0.05) and As (0. 5) mg/kg.

### 2.5.3: Gulf standard (2015)

The maximum levels of heavy metals in meat and meat product lead (0.5), Cadmium (0.5) Mercury (0.1) and Arsenic (0.5) mg/kg.

### 2.5.4: China standard (2006):

The maximum levels of heavy metals in meat and meat product Pb (0.2), Cd (0.1,) Hg (0.05), As (0.05), Cr (1.0) and Ni (1.0) mg/kg

### 2.5.5: Australia New Zealand Food Standards (2015):

The maximum levels of heavy metals in meat and meat product lead (0.1), Cadmium (0.05), Mercury (0.5) and Arsenic (1.0) mg/kg.

# Chapter three

# Materials and methods

## 3.1: study Area and samples collection:

This study was conducted in the college of Animal Production Science and technology - Sudan University of Science and Technology. The study was carried out in the Khartoum state public markets. During the period February 2016 to May 2017. The fresh meat samples (beef, goat and camel) were collected from some public market in Khartoum state (capital of Sudan) in polyethylene bags and was marked according to type of meat, the sausage samples were processed and all samples were stored at -18˚c for analysis in laboratory of meat science and technology – collage of animal production science and technology- Sudan University of Science and Technology, Then the samples were taken for Analysis to Environmental and Natural Resources Desertification Research Institute Laboratory - National Research Council .

## 3.2: preparation and treatment of samples

The collected samples were washed with distilled water to remove any contaminated particles. Then samples were cut to small pieces using clean ceramic knife. Samples were dried in an oven at 100 °C for 2hr. After drying the samples were grained into a fine powder using a ceramic mortar and stored in polyethylene bags until used for acid digestion. The samples were decomposed by wet digestion method for the determination of various metals. A known quantity of 10 g of each sample was introduced into the digestion flask and 20mL of sulphuric acid was added. The digestion flask was heated for 30 min. After digestion, hydrogen peroxide was added drop wise until a clear solution obtained. Then the content of the flask was filtered into a 50 mL volumetric flash and made up to the mark with distilled water. Elemental analysis of samples: for determination of Cd, As, Hg, Cr, Cu, Fe, Mn, Mo, Zn, Ni and Pb in samples were made directly on each of the final solutions using Perkin-Elmer Analyst 300 Atomic Absorption Spectroscupy (AxAS) in the laboratory Environmental and Natural Resources Desertification Research Institute Laboratory - National Research Council. .

### 3.3: Statistical analyses:

The result data was subjected to one way analysis of variance (ANOVA) ($p<0.05$) to general linear model (GLM) flowing by least significant different test (LSD) using the SPSS 17.0 (2007). Computer program

# Chapter Four:

## Result:

The results obtained from this study were presented in table 1, 2, 3, 4, 5 and 6

### 4.1: Heavy metals in fresh meat:

### 4.1.1: Toxic metals in fresh meat:

**Tables (1): The concentration of heavy metals in fresh meat of (beef, goat and camel) mg|kg.**

| **Element** / **Type of meat** | **Lead** | **Cadmium** | **Mercury** | **Arsenic** |
|---|---|---|---|---|
| **Beef** | ND | ND | ND | ND |
| **Goat meat** | ND | ND | ND | ND |
| **Camel meat** | ND | ND | ND | ND |
| **Sig** | NS | NS | NS | NS |

*****ND: Not detection

***NS:** No Significance different

As shown in table (1) there was no significant difference between samples cullected from Khartoum state. All heavy metals (lead, cadmium, mercury and arsenic) in fresh meat were lower than detection limits.

### 4.1.1.1: Lead:

The level of lead in different samples of beef, goat and camel meat was undetectable; as their concentrations were lower than detection limits.

### 4.1.1.2: Cadmium:

The concentration of cadmium in different samples of beef, goat and camel meat was lower than detection limits.

### 4.1.1.3: Mercury

The level of mercury in different samples of beef, goat and camel meat was lower than detection limits.

### 4.1.1.4: Arsenic:

The concentration of arsenic in different samples of beef, goat and camel meat was lower than detection limits.

### 4.1.2: Essential metals in meat:

**Table (2): Essential metals in beef, goat and camel meat (mg|kg):**

| **Element**<br>**Type of meat** | **Cr** | **Mn** | **Zn** | **Ni** | **Cu** | **Fe** |
|---|---|---|---|---|---|---|
| **Beef meat** | 0.52$^{a}$±0.10 | 0.08±0.09 | 0.22±0.18 | 0.34 $^{a}$ ±0.253 | 0.66±0.81 | 56.37±35.03 |
| **Goat meat** | 0.32$^{b}$±0.07 | 0.25±0.29 | 0.39$^{b}$±0.16 | 0.37±0.426 | 0.32±0.29 | 37.20±1.35 |
| **Camel meat** | 0.38±0.12 | DL | 0.43 $^{a}$ ±0.19 | ND$^{b}$ | 0.38±0.12 | 38.40±0.14 |
| **Sig** | ** | **NS** | ** | ** | **NS** | ** |

$^{a}$, $^{b}$ mean with different superscript in the same column are significantly different at (p≤0.05)

**: Significance different p≤0.0

DL: at detection limits (0.01)

ND: Not detection

***NS:** No Significance different

As shown in table (2) there was high significant difference ($P \leq .05$) between samples of fresh meat in chromium, zinc and nickel, but no significant difference (NS) in manganese and cupper.

### 4.1.2.1: Nickel:

Nickel in beef meat samples recorded the highest concentration (0.14) compared with goat and camel meat which were (0.01) and (0.01) mg/kg respectively.

### 4.1.2.2: Zinc:

Zinc in beef meat samples also recorded the highest level as (0.73) compared with goat and camel meat which were (0.67) and (0.71) mg/kg respectively.

### 4.1.2.3: Chromium:

Beef meat also recorded the highest level of chromium (0.52) of compared with goat and camel meat which were (0.32) and (0.38) mg/kg respectively.

### 4.1.2.4: Manganese:

Manganese in goat meat samples recorded the highest concentration (0.25) mg/kg compared with beef (0.08) mg/kg and camel meat was least detection limits (0.001).

### 4.1.2.5: Cupper:

Beef samples also recorded highest level of cupper (0.66) compared with goat and camel meat which were (0.32) and (0.38) mg/kg respectively.

### 4.1.2.6: Iron:

Beef samples collected from Khartoum public market recorded the highest concentration of iron (56.37) compared with goat and camel meat which were (37.20) and (38.40) mg/kg respectively.

## 4.2: heavy metals in sausage:

### 4.2.1. Toxic metals in sausage:

**Table (3): The toxic metals in beef, goat and camel sausage (mg|kg ):**

| Element<br>Type of sausage | Pb | Cd | Hg | As |
|---|---|---|---|---|
| **Beef sausage** | ND | ND | ND | ND |
| **Goat sausage** | ND | ND | ND | ND |
| **Camel sausage** | DL | ND | ND | ND |
| **Sig** | NS | NS | NS | NS |

*ND: Not detection

DL: detection limits.

NS**:** No Significance different.

As shown in table (3) there was no significant different between samples of sausage. All heavy metals (lead, cadmium, mercury and arsenic) in sausage were lower than the detection limits (0.001).

### 4.2.1.1: Lead:

The levels of lead in different samples sausage of beef, goat and camel meat were lower than detection limits

### 4.2.1.2: Cadmium:

The concentration of cadmium in different samples sausage of beef, goat and camel meat was lower than detection limits.

### 4.2.1.3: Mercury

The levels of mercury in different samples of sausage from beef, goat and camel meat was undetectable.

### 4.2.1.4: Arsenic:

The concentration of arsenic in different samples of sausage from beef, goat and camel meat was also undetectable.

### 4.2.2: Essential metals in sausage:

**Table (4): Essential metals in beef, goat and camel meat sausage (mg|kg):**

| **Element**<br>**Type of sausage** | **Cr** | **Cu** | **Mn** | **Zn** | **Ni** | **Fe** |
|---|---|---|---|---|---|---|
| **Beef sausage** | $0.6^{a}\pm0.028$ | $1.07^{a}\pm0.329$ | $0.33\pm0.030$ | $0.72\pm0.16$ | $0.10\pm0.09$ | $76.14^{a}\pm0.76$ |
| **Goat sausage** | $0.27^{b}\pm0.624$ | $0.5^{b}\pm0.036$ | DL | $0.31\pm0.13$ | $0.01\pm0$ | $38.32^{b}\pm0.18$ |
| **Camel sausage** | $0.36^{c}\pm0.083$ | $0.02^{b}\pm0.050$ | $0.04\pm0.046$ | $0.16\pm0.04$ | $0.01\pm0.01$ | $37.81^{b}\pm0.35$ |
| **Sig** | ** | ** | NS | NS | NS | ** |

**: Significance different $p\leq0.01$

DL: at detection limits (0.01)

NS**:** No Significance different.

As shown in table (4) there was high significant difference ($P \leq 0.05$) between sausage samples in Iron, chromium and cupper but there was no significant difference (NS) in nickel, manganese and zinc.

#### 4.2.2.1: Nickel:

The beef samples sausage recorded the highest level of nickel (0.11) compared with goat and camel sausage as (0.01) and (0.01) mg/kg respectively.

#### 4.2.2.2: Zinc:

Zinc in beef sausage samples also recorded the highest concentration (0.75) compared with goat and camel sausage which were (0.58), and (0.66) mg/kg respectively

#### 4.2.2.3: Chromium:

Beef sausage samples recorded also the highest level of chromium (0.61) compared with goat and camel sausage which were (0.27) and (0.36) mg/kg respectively.

#### 4.2.2.4: Manganese:

Beef sausage samples recorded the highest level of manganese as (0.33) compared with goat was (Not Detected) and camel sausage (0.04) mg/kg respectively.

#### 4.2.2.5: Cupper:

Beef sausage also recorded the highest level of cupper (1.07) compared with goat and camel meat which were (0.50) and (0.43) mg/kg respectively.

### 4.2.2.6: Iron:

Beef sausage samples recorded the highest level of iron as (76.14) compared with goat and camel sausage (38.32) and (37.81) mg/kg respectively.

### 4.3.1: Toxic metal in fresh meat and sausage:

**Tables (5): The concentration of heavy metals in fresh meat and sausage (beef, goat and camel) mg|kg.**

| Element / Type of meat | Lead | Cadmium | Mercury | Arsenic |
|---|---|---|---|---|
| **Beef** | ND | ND | ND | ND |
| **Goat meat** | ND | ND | ND | ND |
| **Camel meat** | ND | ND | ND | ND |
| **Beef sausage** | ND | ND | ND | ND |
| **Goat sausage** | ND | ND | ND | ND |
| **Camel sausage** | DL | ND | ND | ND |
| **Sig** | NS | NS | NS | NS |

*ND: Not detection

*****DL: detection limits.

*NS**:** No Significance different.

As shown in table (5) there was no significant difference between samples of fresh meat and sausage. All heavy metals (lead, cadmium, mercury and arsenic) in fresh meat and sausage were not detection limits.

### 4.3.1: Lead:

The levels of lead in different fresh meat and sausage samples of beef, goat and camel meat was not detected; as their concentrations were lower than detected.

### 4.3.2: Cadmium:

The concentration of cadmium in different meat and sausage samples of beef, goat and camel meat was lower than detection limits

### 4.3.1.3: Mercury

The level of mercury in different fresh meat and sausage samples from beef, goat and camel meat was lower than detection limits

### 4.3.1.4: Arsenic:

The concentration of cadmium in different fresh meat and sausage samples from beef, goat and camel meat was lower than detection limits.

### 4.3.2: Essential metals in meat and sausage:

**Table (6): Essential metals in fresh meat and sausage of beef, goat and camel (mg|kg).**

| **Element**<br>**Type of meat** | **Cr** | **Mn** | **Zn** | **Ni** | **Cu** | **Fe** |
|---|---|---|---|---|---|---|
| **Beef meat** | 0.52$^{a}$±0.10 | 0.08±0.09 | 0.22±0.18 | 0.34±0.25 | 0.66±0.81 | 56.37$^{a}$± 35.03 |
| **Goat meat** | 0.32$^{b}$±0.07 | 0.25±0.29 | 0.39±0.16 | 0.37±0.43 | 0.32±0.29 | 37$^{b}$20.±1.35 |
| **Camel meat** | 0.38±0.12 | DL | 0.43 ±0.19 | ND | 0.38±0.12 | 38.40$^{b}$±0.14 |
| **Beef sausage** | 0.6$^{a}$±0.03 | 0.33±0.03 | 0.72±0.160 | 0.10±0.09 | 1.07 $^{a}$±0.33 | 76.14$^{a}$±0.76 |
| **Goat sausage** | 0.27$^{b}$±0.62 | DL | 0.31±0.132 | 0.01±0 | 0.5$^{b}$±0.04 | 38.32$^{b}$±0.17 |
| **Camel sausage** | 0.36 $^{c}$±0.08 | 0.04±0.05 | 0.16±0.038 | 0.01±0.01 | 0.02$^{b}$± 0.05 | 37.81$^{b}$± 0.35 |
| **Sig** | ** | NS | NS | NS | NS | ** |

$^{a}$, $^{b}$ mean with different superscript in the same column are significantly different at ($p \leq 0.05$)

**: Significance different $p \leq 0.0$

*NS**:** No Significance different.

DL : at detection limits (0.01)

ND: Not detection

As shown in table (6) there was high significant difference ($P \leq 0.05$) between fresh meat and sausage samples in Iron and chromium, but no significant different (NS) in nickel, cupper, manganese and zinc as showed in table (6).

### 4.3.2.1: Nickel:

Goat meat samples recorded the highest level of nickel (0.36) mg/kg of compared with other fresh meat and sausage

### 4.3.2.2: Zinc:

Zinc in beef sausage samples recorded the highest concentration as (0.75) mg/kg compared with other fresh meat and sausage

### 4.3.2.3: Chromium:

Beef sausage samples recorded the highest level of chromium as (0.60) mg/kg of compared with other fresh meat and sausage.

### 4.3.2.4: Manganese:

Beef sausage recorded the highest level of manganese as (0.33) mg/kg of compared with other fresh and sausage

### 4.3.2.5: Cupper:

Beef sausage recorded the highest level of cupper as (1.08) mg/kg compared with other fresh meat and sausage

### 4.3.2.6: Iron:

Beef sausage recorded also the highest level of iron (76.14) mg/kg compared with other fresh meat and sausage.

# Chapter Five

## Discussion:

### 5.1: Toxic metals in meat:

#### 5.1.1: Lead:

In this study the level of lead was less than (0.001) which conformed to some international standards e.g; Food and Agricultural Organization (FAO, 2002), European Commission (EC 1881, 2006), Food Standards Australia New Zealand (FSANZ, 2003), China standards (2015) and Gulf standard (2015). This results also agreed with Makanjuola and Olakunle (2016) who found level of lead in some meat samples was lower than detection limits (0.001). This result disagreed with Amani and Lamia (2012) who reported, the level of lead in beef, goat and camel meat as (7.61), (6.35) and (5.48) mg|kg respectively, this result also disagreed with Bendeddouche *et al.,* (2014) who found, the concentration of lead in beef, goat and camel meat as (7.76), (3.49) and (2.01)mg/kg respectively.

#### 5.1.2: Cadmium:

In the present study the concentration of cadmium was less than (0.001) which is conformed USDA (2006), European Commission (EC 1881, 2006), gulf standard (2015), JEFCA, (2004), Food Standards Australia New Zealand (FSANZ, 2003) and china (2006), this result similarly agreed with Makanjuola and Olakunle (2016) who found concentration of cadmium in some meat samples was lower than detection limits (0.001). However, the results disagreed with Chafik (2014) who reported the concentration of cadmium in beef, sheep and camel as (0.00, 0.00 and 0.12) mg/kg respectively, also disagreed with

Amani and Lamia (2012) who reported, the cadmium in beef, goat and camel meat as (1.68), (1.25) and (1.07) ppm respectively, also disagreed with Bendeddouche *et al.,* (2014) who found the concentration of cadmium in beef, goat and camel meat as (1.65), (1.93) and (0.91) mg/kg respectively.

### 5.1.3: Mercury

The concentration of mercury was less than (0.001) which was conformed with USDA, (2006), European Commission (EC 1881, 2006), FAO (2003) ,Food Standards Australia New Zealand (FSANZ, 2003) , China standard (2006) and gulf standard (2015). This result also agreed with Makanjuola and Olakunle (2016) who found concentration of mercury in meat samples lower than detection limits (0.001). However, This result disagreed with Marian and Jonathan (2014) who found, mercury in beef and chevon as (0.052) and (0.034) ppm respectively, also disagreed with Bendeddouche *et al.,* (2014) who found the concentration of mercury in beef, goat and camel meat as (0.051) ,(0.027) and (0.032) mg/kg respectively.

### 5.1.4: Arsenic:

In the present study the concentrations of arsenic was less than (0.001) which is conformed with USDA, (2006), European Commission (EC 1881, 2006), FAO (2003), Food Standards Australia New Zealand (*FSANZ, 2003)*, China standard (2006) and Gulf standard (2015), This result also agreed with Makanjuola and Olakunle (2016) who reported concentration of mercury in meat samples lower than detection limits (0.001). However, the result of this study disagreed with Akan *et al.,* (2010) who reported , arsenic concentrations in the meat of beef, mutton, caprine and chicken as ranged from (0.01 to 0.13) mg/kg, also disagreed with Zahurul *et al.,* (2011) who found the arsenic in beef as (0.18) and goat meat as(0.33) mg/kg.

### 5.1.2: Essential metals:

### 5.1.2.1: Nickel:

In the present study the concentration of nickel in meat was (0.05) mg\kg which is which quite similar in comparison with the standard value. According to Food and Agriculture Organization, the standard value of nickel for food items is 5 mg/kg, which agreed With Akan *et al* .,(2010) who found , nickel concentrations in the meat of beef, mutton, caprine and chicken as ranged from (0.01 to 0.22) mg/kg. And also agreed with Makanjuola and Olakunle Moses (2016) who found concentration of nickel in meat as 0.01-0.56 mg/kg. However, this result disagreed with Zahurul *et al* (2011) who reported the nickel in beef as (2.64) and goat meat as (0.35) mg/kg. Also disagreed with Sathyamoorthy *et al.,* (2016) who found the concentration of nickel in meat as (22.1) mg|kg

### 5.1.2.2. Zinc:

In the present study, the concentration of zinc was (0.34) mg\kg which is conformed to FAO, (2002) who stated the Zinc concentration in meat and meat product was below the allowed limit (50 mg/kg). This result also agreed with Akan *et al* (2010) who found, zinc concentrations in the meat of beef, mutton, caprine and chicken as ranged from (0.10 to 2.04) mg/kg. However, the result disagreed with Amani and Lamia (2012) who reported, the zinc in beef and goat and camel meat as (41.72), (33.85) and (16.74) mg/kg respectively. Also disagreed with Bendeddouche *et al* (2014) who found, the concentrations of zinc in beef, goat and camel meat as (36.99), (39.64) and (23.51) mg/kg respectively.

### 5.1.2.3: Chromium:

The levels of chromium in this study was (0.4) mg/kg in meat which is conformed to USDA (2006) and China standards (2006) who stated the maximum level of chromium in meat as 1.0 mg/kg. This result agreed with Marian and Jonathan (2014) who reported, chromium in beef and chevon as (0.304) and (0.632) ppm respectively. Also agreed with Akan *et al.,* (2010) who found, the chromium concentrations in the meat of beef, mutton, caprine and chicken as ranged from (0.15 to 0.43) mg/kg. And agreed with Zahurul et *al.,*(2011) who found the concentration of Cr in animal meat and meat products were in the range of 0.02-5.36 mg/kg, and 2.89-4.33 mg/kg respectively. However, this result disagreed with Zahurul *et al* (2011) who found the chromium in beef as (1.22) mg/kg and goat meat (0.08) mg/kg.

### 5.1.2.4. Manganese:

The concentration of manganese in the present study was (0.15) mg\kg in meat, which was similar to Cabrera *et al.,* (2010) who Estimated Safe and Adequate Daily Dietary Intake (ESADDI) for manganese as 2-5mg/kg. The result agreed with Akan *et al* .,(2010) found , manganese concentrations in the meat of beef, mutton, caprine and chicken was in the range of (0.45 to 3.20) mg/kg. However the results disagreed with Amani and Lamia (2012) who reported the manganese in beef, goat and camel meat as (1.01), (1.01) and (0.88) mg/kg respectively. Also disagreed with Farooq Ahmad (2016) who found the concentration of manganese in meat as 0.0124 mg/kg

### 5.1.2.5. Cupper:

The concentrations of cupper in this study was (0.663) mg/kg which was lower than that reported by González *et al.,* (2014 ) who found cupper in red meat as 0.87 mg|kg, however, the result disagreed with Bendeddouche *et al.,* (2014) who found the level of cu in beef, sheep and camel meat (12.37) (2.56) and (2.82) mg|kg respectively.

### 5.1.2.6. Iron:

In the present study, the level of iron was (43.99) mg|kg. This results was lower than that reported by Bendeddouche, *et al.,* (2014) for Beef as (84.22) Sheep as (70.36) and Camel meat as (75.03) mg/kg. Also disagreed with González *et al.,* (2014) who reported iron in red meat as 12.93 mg|kg.

## 5.2: Heavy metals in sausage:

### 5.2.1. Toxic metals:

### 5.2.1.1. Lead:

In the present study the result showed that, the levels of lead was lower than 0.001 which is conformed to European Commission (EC 1881, 2006), China standard (2006), Gulf standards (2015) and Food Standards Australia New Zealand (FSANZ, 2015). However, this result disagreed with Gonzales-Waller *et al.,* (2006) who reported the mean concentration of lead in the pork meat products 6.72 ppb and in the beef products 9.12 ppb. Also disagreed with Demirezen and Uruc (2006) who found the average lead concentrations obtained from pastirma, meat and sausage as 0.126, 0.115, 0.135 mg/kg respectively. And disagreed with Abedi (2011) who reported the lead content in sausages from Irapn as 53.5 mg/kg. And González et al., (2006) who found Concentrations of lead in chicken meat product samples as (3.16) mg/kg, pork meat product (4.89) mg/kg, and (4.76) mg/kg in beef meat product. Also disagreed with

Santhi *et al.,* (2008) who reported relatively higher lead content in bacon as (1.641) mg/kg, ham (1.966) mg/kg, sausage (1.352) mg/kg, salami (3.250) mg/kg and luncheon meat (2.231) mg/kg obtained from retail outlets of Chennai city, and disagreed with Dora *et al.,* (2014) who found lead in sausage as 9.0 mg/kg.

### 5.2.1.2: Cadmium:

in this study, the cadmium concentrations was lower than detection limits (0.001) which is conformed with European Commission (EC 1881, 2006), China standard (2015), Gulf standard (2015) and Food Standards Australia New Zealand (FSANZ, 2015). However, this result disagreed with Amani and Lamia (2012) who reported the cadmium in sausage as (3.33) mg/kg. And disagreed with Abedi (2011) who found the cadmium content in sausages from Iran as 5.7cd mg/kg. And disagreed with González *et al.,* (2006) who found Concentrations of cadmium in chicken meat product were (4.15) mg/kg, pork meat as (6.50) mg/kg and (4.76) mg/kg in beef meat product. Also disagreed with Dora *et al.,* (2014) who found the trace metals cadmium in sausage as 1.9 mg/kg.

### 5.2.2.3: Mercury:

In the present study the mercury concentration was less than detection limits (0.001) which is similar to European Commission (EC 1881, 2006), China standard (2015), Gulf standard (2015) and Food Standards Australia New Zealand (FSANZ, 2015). This result disagreed with Dora *et al.,* (2014) who found the mercury in sausage as 1.053 mg/kg. Also disagreed with Amani and Lamia (2012) who found the mercury in sausage 0.014–0.055 mg/kg.

### 5.2.2.4: Arsenic:

The concentration of arsenic in this study was lower than detection limit (0.001) which is conformed European Commission (EC 1881, 2006), China standard (2006), Gulf standard (2015), and Food Standards Australia New Zealand (FSANZ, 2015). This result disagreed with Dora *et al.,* (2014) who found the concentration of arsenic in sausage as 18 mg/kg. Also disagreed with Amani and Lamia (2012) who found the concentration of arsenic in sausage as 0.125 mg/kg.

### 5.2.2: Essential element:

### 5.2.2.1:Nickel:

In the present study the nickel concentration in sausage was 0.04 mg|kg which disagreed with Ijaz *et al.,(*2013) who found Concentration of nickel in goat meat as (2.335 -13.271) mg|kg. And disagreed with Sathyamoorthy *et al.,* (2016) who found nickel in meat as (22.1) mg|kg, also disagreed with Demirezen and uric *et al.,* (2006) who found nickel in meat and meat products a range of 8.2- mg/kg

### 5.2.2.2. Zinc:

In this study, the concentration of zinc in sausage was 0.05 mg|kg which was similar to FAO, (2002) who stated the Zinc concentration in meat and meat product was below the allowed limit as 50 mg/kg. However, this result disagreed with Amani and Lamia (2012) who reported the zinc in sausage as 16.79–49.43 mg/kg. Also disagreed with Dalia and Bassma, (2015) who found the concentration of zinc in sausage as 38.59 mg/kg.

### 5.2.2.3.Chromium:

In the present study, the concentration of chromium in sausage was 0.41 mg|kg which is similar to china standard (2006) and USDA (2006). This results also Agreed with Zahurul *et al.,* (2011) who found the concentration of chromium in meat products is in the range of 2.89-4.33 mg/kg.

### 5.2.2.4.Manganese:

The concentration of manganese in this study was 0.13 mg/kg which disagreed with González *et al.,* (2014) who reported the level of manganese in sausage as 0.56 mg|kg, and disagreed with Amani and Lamia (2012) who found manganese in sausage as 7.72–13.99 mg/kg. Also disagreed Dalia and Bassma, (2015) who found manganese in sausage as (8.4) mg/kg. And disagreed Zahran and Hendy ( 2015) who reported the concentration of manganese in sausages which ranged from3.32–18.38 mg/kg .

### 5.2.2.5: Cupper:

In this study, the level of cupper in sausage was 0.53 mg|kg which was lower than Dalia and Bassma, (2015) who found cupper concentration in sausage as 3.45 mg/kg, also lower than Amani and Lamia (2012) who found the levels of cupper in sausage as 2.3–12.05 μg/g. However, this result was less than González *et al.,*(2014) who reported cupper in sausage as (1.13)mg|kg.

### 5.2.2.6. Iron:

In the present study, the concentration of iron in sausage was 50.77 mg|kg, which in the range that reported by Amani and Lamia (2012) as 44.87–250.23 mg/kg. However, this result disagreed with Dalia and Bassma, (2015) who found iron concentration in sausage as 135 mg/kg. disagreed with González *et al* (2014) who found the level of iron in sausage as (12.54) mg|kg, also disagreed with Zahran and Hendy (2015) who found the concentration of iron in sausages was ranged from 82.9 to 270 mg/kg.

### 5.3.: Heavy metals in fresh meat and sausage:

### 5.3.1: Toxic metals:

### 5.3.1: Lead:

In this study the level of lead in fresh meat and sausage were less than detection limits (0.001) which is conformed with Food and Agricultural Organization (FAO, 2002), European Commission (EC 1881, 2006), Food Standards Australia New Zealand (FSANZ, 2003), Chain (2015) and Gulf standard (2015).

### 5.3.2: Cadmium:

In the present study the concentration of cadmium in fresh meat and sausage were less than detection limits (0.001) which is conformed USDA (2006), European Commission (EC 1881, 2006), gulf standard (2015), (JEFCA, 2004), Food Standards Australia New Zealand (FSANZ, 2003) and china standards (2006).

### 5.3.3: Mercury

The concentration of mercury in fresh meat and sausage were lower than the detection limits (0.001) which is conformed with USDA, (2006), European Commission (EC 1881, 2006), FAO (2003) ,Food Standards Australia New Zealand (*FSANZ, 2003) , China standard (2006) and* gulf standard (2015).

### 5.3.4: Arsenic:

In the present study the concentrations of arsenic in fresh meat and sausage were less than (0.001) which is conformed with USDA, (2006), European Commission (EC 1881, 2006), FAO (2003), Food Standards Australia New Zealand (*FSANZ, 2003)* , China standard (2006) and gulf standard (2015),

### 5.3.2: Essential metals:

### 5.3.3.1: Nickel:

In the present study the concentration of nickel in fresh meat and sausage were (0.05) and (0.04) mg| kg respectively. Which is agreed with Akan *et al.,* (2010) who found , nickel concentrations in the meat of beef, mutton, caprine and chicken as ranged from 0.01 to 0.22 mg/kg. Also agreed with Makanjuola and Olakunle Moses (2016) who found the range of nickel in meat as 0.01-0.56 mg/kg. However, this result disagreed with Zahurul *et al,,* (2011) who reported the nickel in beef as 2.64 and goat meat as 0.35 mg/kg, and disagree with Sathyamoorthy *et al.,* (2016) who found nickel s in meat as 22.1 mg|kg

### 5.3.2.2.Zinc:

In the present study the concentration of zinc in fresh meat and sausage were 0.345 and 0.409 mg|kg respectively, which is conformed to FAO, (2002) who stated, the zinc concentration in meat and meat product was below the allowed limit of 50 mg/kg. However, this result disagreed with Amani and Lamia (2012) who reported the zinc in meat and meat product 16.74–147.82 and 30.34–73.94 μg/g. Also disagreed with Dalia and Bassma, (2015) who found Zinc concentration in sausage as (38.59) ppm. González *et al,,*(2014) who reported the concentration of zinc in meat and sausage as 33.15 and 20.54 mg|kg respectively.

### 5.3.2.3. Chromium:

The result of this study showed that the concentration of chromium in fresh meat and sausage is 0.03-0.5 and 0.2- 0.6 mg\kg respectively, which is less than USDA (2006) and China standards (2015) who stated, the maximum level of chromium in meat and meat product as 1.0 mg/kg. This results agreed with Zahurul *et al.,* (2011)who found the concentration of chromium in meat was lower than meat products.

### 5.3.2.4. Manganese:

The concentration of manganese in fresh meat and sausage were 0.15 and 0.13 mg \kg respectively. Which is agreed with *González et al* (2014) who reported the level of manganese in meat and sausage as 0.11 and 0.56 mg|kg. However, this result was lower than that reported by Dalia and Bassma, (2015) who found manganese in sausage as (8.4)ppm. This result was higher than González *et al.,* (2014) who found manganese in sausage as 0.56 mg|kg.

### 5.3.2.5. Cupper:

In this study, the concentration of cupper in fresh meat and sausage were 0.45 and 0.53 mg|kg respectively. Which is lower than finding of Dalia and Bassma, (2015) who found cupper concentration in sausage as (3.45) mg/kg, also lower than Amani and Lamia (2012) who found the level of cupper in sausage as (2.3–12.05) mg/kg. This result also lower than that reported by González *et al,,* (2014) the concentration of cupper in meat and sausage as 0.87 and 1.13 mg/kg respectively.

### 5.3.2.6. Iron:

In the present study levels of iron in fresh meat and sausage were 43.99 and 50.77mg |kg respectively, which is lower than finding of Dalia and Bassma, (2015)who reported the iron concentration in sausage as (135) mg/kg. This result higher than González *et al*,, (2014)who found the level of iron in meat and sausage as 12.93 and 12.53 mg| kg respectively. This result disagreed with Amani and Lamia (2012) who found the levels of iron contents in meat and meat products ranged between 68.7–290.0 and 175.69–242.44 mg/kg respectively.

## Conclusion and Recommendation:

### Conclusion:

All samples of fresh meat and sausage were safe and free of heavy metals and were similar to international standards. The essential elements of fresh meat and sausage in this study were less than the standards limits.

### Recommendation:

- Further studies should be carried out in this field to produce meat and meat products that match with international standards of food safety.

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