ASSESSMENT OF SOME MINERAL CONTAMINATION OF MEATS SINGEING WITH SCRAP TYRES AND PLASTIC WASTES

Supported by tetfund TERTIARY EDUCATION TRUST FUND

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Received: April 18, 2017 **Accepted:** August 22, 2017

Abstract: Analysis of some mineral contamination of cow, sheep and goat meats (unwashed and washed) through the use of scrap tyre for singeing as the processing method was carried out in some of the states in Northern part of the country (Nigeria) to determine the level of these mineral (As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, and Zn). All the meat samples contained the mineral determined. The overall results in cow meat samples ranged from 0.187 – 0.211, 0.321 – 0.953, 0.351 – 0.987, 0.245 – 0.967, 0.875 – 2.231, 18.354 – 27.765, 2.234 – 4.321, 0.932 – 1.097, 0.110 – 0.879 and 3.456 – 9.765 µg/g for unwashed cow meat and 0.157 – 0.999, 0.225 – 0.747, 0.257 – 0.886, 0.205 – 0.869, 0.679 – 2.031, 19.054 – 23.761, 2.031 – 3.021, 0.732 – 1.007, 0.110 – 0.876 and 2.456 – 8.569 µg/g in washed cow meat samples for As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn respectively. In unwashed sheep meat samples the concentration of the mineral determined ranged from 0.157 – 0.918, 0.299 – 0.858, 0.451 – 0.884, 0.235 – 0.869, 0.776 – 2.031, 16.334 – 26.725, 2.331 – 3.922, 0.831 – 1.034, 0.110 –0.770 and 2.456 – 10.765 and for the washed sheep meat samples the level of the same minerals ranged from 0.139 – 0.818, 0.209 – 0.759, 0.399 – 0.798, 0.245 – 0.854, 0.707 – 2.130, 18.334 – 29.765, 2.237 – 3.022, 0.735 – 0.989, 0.110 – 0.655 and 2.058 – 10.063 µg/g for As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn, respectively while in the goat meat samples the concentration of the mineral ranged from 0.137 – 0.801, 0.299 – 0.853, 0.356 – 0.882, 0.255 – 0.861, 0.779 – 2.039, 18.099 – 28.765, 3.234 – 4.922, 0.839 – 1.013, 0.130 – 0.896 and 3.552 – 9.961 for unwashed goat meat and 0.117 – 0.799, 0.219 – 0.875, 0.296 – 0.771, 0.215 – 0.751, 0.674 – 2.002, 19.099 – 30.065, 3.034 – 4.221, 0.631 – 1.001, 0.110 – 0.799 and 3.652 – 9.061 µg/g in washed goat meat samples for As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn, respectively. The mean concentration (µg/g) of the mineral of the regularly slaughtered meats singed with scrap tyres and plastic wastes were significantly higher than the mean concentration observed in raw, fresh and unprocessed meats. It was revealed that the uses of scrap tyres and plastic materials are the highest contributors of these toxic metals to singed meats. The sources of these mineral in these materials are linked to the composition of the raw materials from which the items were derived from. The concentrations of some the minerals like Fe, Cd, Cr, Cu and Zn exhibited some pattern where the unwashed singed meat showed lower concentration, increased after washing with the water. This implies that the water used for washing the meat probably contributed to the level of these minerals in the meat also.

Keywords: Contamination, meat, minerals, northern Nigeria, plastic wastes, singeing

Introduction

Minerals are defined as the elements in their simple inorganic form (Kirik and Sawyer, 1991). In nutrition they are commonly referred to as mineral elements or inorganic nutrients. There are many mineral elements, which have been proved essential in nutrition. These minerals exist in the body and food, in organic and inorganic combinations. The human body contains minerals in relatively finite amounts and in view of their great importance, the amount seem minimal indeed. The minerals found in the body and food is classified as macronutrients and micronutrients (Kirik and Sawyer, 1991). Mineral elements have many essential roles, both in ionic forms in solution in body fluids and as constituents of essential compounds. Minerals are supplied to the body in the form of salts, found mixed or combined with carbohydrate, fat and protein in natural foods. Macronutrient minerals elements are essential minerals for nutrition while micronutrients play little importance part in the development of the body.

Generally, micronutrients or trace elements are toxic when intake levels, slightly exceed the normal functional level (Kirik and Sawyer, 1991). Food contaminants (mineral, plant, animal, chemical and microbial) are described as undesirable substances that may be found in foods or meats (Brenan *et al.*, 1991). Metal contaminant which are part of mineral contaminant are inorganic element that may be present in food or meat usually in amount well below 50 mg/kg and which have some toxicological or nutritional significance on the body of the consumers. The essential nutritive elements include Co, Cu, Fe, I, Mn and Zn. The nonnutritive elements include Al, Br, Cr, Ni and Sn together with As, Sb, Cd, Fa, Ob, Hg and Se which are known to have deleterious effects even when the diet contains less than 10 to 50 mg/kg (Kampster, 1976).Elements such as copper and zinc, although essential for life processes when in trace, however, have an emetic action when ingested in higher amounts (Brenan *et al.*, 1991).

Mineral contaminants present in foods may be due to a generalized situations arising from the use of a particular processing or method mode of storage and distribution of the food. Mineral contaminants in food are derived from processing machinery, kitchen knives, pots and pans or from particle of soil (Emedo*et al.*, 1985). Other sources may include sprays and dust used as insecticides for the manufacture of raw materials or the dissolution of metals from processing equipment or container (Kampster, 1976).

Food safety issues have become a major concern to consumers and health based organisations. FAO/WHO (2000) noted that outbreak of food borne diseases was on the increase and international food trade was confronted with many disputes over food safety and quality requirements by countries and consumers. Food contamination at every stage of the food production chain is unacceptable since it threatens the health of consumers of such foods. Demand for protein food from both plants and animal sources have increased to address malnutrition issues (Obiri*et al.*, 2008). Scrap tyres and other plastic wastes are known to contain different compounds with heavy metals and other dangerous compounds (Grosse-Daldrup and Scheubel, 1996). The used tyres and plastic wastes which are synthetic products as an alternative solid fuel for singeing meat and meat products are common practises in many urban and rural areas in the developing countries. But before using any material as an alternative fuel (scrap tyre or plastic wastes) the toxicity (organic compounds, inorganic compounds), composition, content of ash, content volatiles, calorific value, should be evaluated first. Many studies have indicated the presence of some metals in tyre wear debris to include Mn, Fe, cobalt (Co), Nickle (Ni), Copper (Cu), Cadmium (Cd), and Lead (Pb) and other toxic substances (Mokrzycki and Uliasz- Bochen'czyk, 2003). Research had indicated that Zn accounts for about 1% by weight of tyre tread material which can be release into the environment in significant quantities through tyre wear (Adachi and Tainosho, 2004, Blok 2005). Several trace elements have been used in tyre manufacture, including Cd, Cu, (Pb), and Zn (Thorpe and Harrison 2008). The implication is that scrap tyres contain some amount of heavy metals which can be released into the environment through several ways such as combustion and tyre wearing. Therefore the use of scrap tyres and plastic wastes for singeing meat is worrying since it can introduce different contaminants into the meat, thereby rendering it unsafe for human consumption. The use of scrap tyres and plastic wastes for singeing meat also pose a serious public health risk to people working in and living around that slaughter places because the open burning practices can release volatile organic compound and polycyclic aromatic hydrocarbons (PAHs) into the environment (Afriyie-Gyawu*et al.*, 2013).

The general conditions of slaughter places in most of our environment both in rural and urban areas have been studied and the use of scrap tyre and plastic wastes especially in an urban areas for singeing meats was identified in several locations within Nassarawa, Benue and Taraba States in Northern part of the country (Nigeria) with conclusion that the practices has become norm. The reasons why butchers have resorted to the use of scrap tyres are well known; the availability issue was also prominent because they claimed that the scrap tyre was like waste to the vulcanising shops where they normally get them from. They also indicated that the fuel woods are sometimes scarce and difficult to access. On the safety of the meat, they indicated that they have no idea what may be the specific health effect of the use of the scrap tyres on their health and on the meat. Several studies have identified high levels of some heavy metals in scrap tyres. Consumption or exposure to high level of various heavy metals has many burdens on different organs of the body, for example Cu is known to cause damage to the liver; Pb may cause cognitive development problems, increase blood pressure and cardiovascular diseases; Hg can cause low intelligent quotient and may affect the kidney, Zn has been found to produce adverse nutrient interactions with Cu (FDA, 2001; Ikem&Egiebor, 2005). Others have found that Zn reduces immune function and the levels of high density lipoproteins. A metal like Cd can cause kidney dysfunctions and reproductive deficiencies (FDA, 2001; Ikem&Egiebor, 2005).

Several researches have been carried out on various meat processing methods in other part of the world (Odoh*et al.*, 2915; Obiri-Danso*et al*., 2008; Obiri-Danso*et al*., 2008; Essumang*et al.,* 2007) reported on elevated levels of some heavy metals in meats which shows that processing methods can affect the quality of meat produced for consumption. Unsuspecting consumers of meat from such slaughter places are ingesting unknown quantities of heavy metals such as Fe, Hg, Cr, Cu, Cd, Pb, and Zn into their bodies due to the use of scrap tyres and plastic wastes in singeing such meat. These heavy metals could significantly compromise the quality of the meat because they have various degrees of health effects on consumers and are bio-accumulative and can be bio-concentrated in organisms and therefore affect the food chain. However, since the Environmental Health Officers, have not stopped or cautioned them that it can have some effect on the quality of the meat and their own health. Their perception about the safety of the meat produced in the process is not well captured in their minds. Therefore, this study aimed at investigating the mineral contamination of meats singeing using tyre scraps and other plastic wastes consumed in the study areas

Materials and Methods

Sample collection and Treatment

The meat samples used for the analysis were purchased from the butchers who normally slaughter animals at each of the study areas (Abattoir sites) which use scrap tyres and other plastic materials in singeing these meat materials such as cow hides. These butchers were purposively selected because they were regular users of these materials (scrap tyres and plastic materials) in their slaughter places and have been doing this work for the past years. The study also concentrated on laboratory analysis of 10 composite samples of singed meat of cattle, sheep and goats at three (3) different stages: singed unwashed, singed and washed and singed washed and boiled meat from slaughter places sampled across the study areas. It is important to state that, the hides of animals slaughtered at the slaughter house were not removed and therefore are consumed together with the other parts of the meat, hence the sample.

Laboratory analysis of the different stages of the meat samples were carried out for the levels of selected mineral elements (As, Cd, Co. Cr, Cu, Fe, Pb, Mn, Ni and Zn) after digestion. Approximately 3.00 g portions of the singed meat were carefully taken from cow, sheep and goat directly from the butchers in two separate occasions. Each sample was oven dried at 105ºC to constant weight, homogenized using porcelain mortar and pestle into a powdered form and wet digested.A procedure recommended by Environmental Protection Agency (EPA, Method 3050B) was used as the conventional acid extraction method. 3.00 g of sample was placed in 250 ml flask for digestion. The first step was to heat the sample to 95^0C with 10 ml of 50% HNO_3 without boiling. After cooling the sample, it was refluxed with repeated additions of 65% HNO_3 until no brown fumes were given off by the sample. Then the solution was allowed to evaporate until the volume was reduced to about 5 cm^3. After cooling, 10 ml of 30% H_2O_2 was added slowly without allowing any losses. The mixture was refluxed with 10 cm^3 of 37% HCl at 95^0C for 15 min. The digestate obtained was filtered through a 0.45 µm membrane paper, diluted to 100 cm^3 with deionized water and stored for analyses. The total extraction procedure lasted for 3 – 4 h. The resultant solution was cooled and filtered into 100 cm^3 standard flasks and made to mark with distilled water (Asaolu, 1995). Atomic absorption spectrophotometer (Buck scientific model 200A) was used for As, Cd, Co. Cr, Cu, Fe, Pb, Mn, Ni and Zn. Standards for atomic absorption analysis were prepared from commercial stock metal standards of each metal determined. Levels of each metal in each digested samples were determined in triplicates using Atomic Absorption Spectrophotometer, with the blank solution set as zero (0) and the standards used for calibration of the spectrophotometer.

Results and Discussion

The concentrations of the various minerals found in the meat samples from the animals commonly singed with scrap tyres and plastic wastes (unwashed and washed) are presented in Tables 1, 2 and 3. Table 1 represent the cow meat samples (beefs), Table 2 represent sheep meat samples (muttons) and Table 3 represent the goat meat samples (caprine) bought from various slaughter houses in the study areas. Table 4 represent the control meat samples from the same areas. Control was the direct raw, fresh, unsigned and unprocessed meat which was obtained from the each animal meat being considered from the study.

Table 1: Range and average levels of minerals (μg/g) in unwashed and washed cow meats (Beefs) singed with scrap tyres and plastic wastes

Elements	Unwashed meat		Washed meat	
	Range	Mean±SD	Range	Mean±SD
As	0.187 – 0.211	0.695±0.011	0.157 – 0.999	0.443±0.042
Cd	0.321 – 0.953	0.653±0.005	0.225 – 0.757	0.453±0.003
Co	0.351 – 0.987	0.732±0.023	0.257 – 0.886	0.534±0.026
Cr	0.245 - 0.967	0.876±0.032	0.205 - 0.869	0.771±0.012
Cu	0.875 – 2.231	1.987±0.987	0.679 – 2.031	1.187±0.283
Fe	18.354– 27.765	22.123±1.225	19.054– 28.761	23.123±0.922
Mn	2.234 – 4.321	3.017±0.123	2.034 – 3.021	2.914±0.121
Ni	0.932 – 1.097	0.997±0.123	0.732 – 1.007	0.896±0.122
Pb	0.110 – 0.876	0.543±0.024	0.110 – 0.876	0.513±0.022
Zn	3.456 – 9.765	7.234±0.354	2.456 – 8.569	6.234±0.253

Table 2: Range and Average Levels of Minerals (μg/g) in Unwashed and Washed Sheep Meats (Muttons) Singed with Scrap Tyres and Plastic Wastes

Elements	Unwashed meat			Washed meat
	Range	Mean±SD	Range	Mean±SD
As	0.157 – 0.918	0.582±0.014	0.139 – 0.818	0.498±0.015
Cd	0.299 – 0.858	0.559±0.012	0.209 – 0.759	0.457±0.019
Co	0.451 – 0.884	0.772±0.021	0.399 – 0.798	0.671±0.025
Cr	0.235 – 0.869	0.599±0.032	0.245 – 0.854	0.534±0.031
Cu	0.776 – 2.031	1.887±0.384	0.707 – 2.130	1.987±0.281
Fe	16.334– 26.725	21.023±0.925	18.334– 29.765	23.023±0.325
Mn	2.331 – 3.922	2.917±0.121	2.237 – 3.022	2.113±0.111
Ni	0.831 – 1.034	0.898±0.122	0.735 – 0.989	0.692±0.121
Pb	0.110 – 0.770	0.515±0.015	0.110 – 0.655	0.414±0.013
Zn	2.456 – 10.765	7.234±0.354	2.058 – 10.063	6.232±0.214

The result revealed clear elevated levels of these minerals As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn determined in the meat samples from the study areas, because the mean concentration of each minerals obtained from the control meat samples was consistently low, much lower than those obtained from the meat samples singed with scrap tyres and plastic wastes under consideration. This reflects a general contamination of the meat samples by the various minerals considered in this study. All the minerals considered As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn showed little variations among animals and the processing methods used example unwashed and washed sample types but the difference was not significant (p >0.05). The overall results in cow meat samples ranged from 0.187 – 0.211, 0.321 – 0.953, 0.351 – 0.987, 0.245 – 0.967, 0.875 – 2.231, 18.354 – 27.765, 2.234 – 4.321, 0.932 – 1.097, 0.110 – 0.879 and 3.456 – 9.765 μg/g for unwashed cow meat and 0.157 – 0.999, 0.225 – 0.747, 0.257 – 0.886, 0.205 – 0.869, 0.679 – 2.031, 19.054 – 23.761, 2.031 – 3.021, 0.732 – 1.007, 0.110 – 0.876 and 2.456 – 8.569 μg/g in washed cow meat samples for As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn, respectively.

In unwashed sheep meat samples the concentration of the minerals determined ranged from 0.157 – 0.918, 0.299 – 0.858, 0.451 – 0.884, 0.235 – 0.869, 0.776 – 2.031, 16.334 – 26.725, 2.331 – 3.922, 0.831 – 1.034, 0.110 –0.770 and 2.456 – 10.765 and for the washed sheep meat samples the level of the same minerals ranged from 0.139 – 0.818, 0.209 – 0.759, 0.399 – 0.798, 0.245 – 0.854, 0.707 – 2.130, 18.334 – 29.765, 2.237 – 3.022, 0.735 – 0.989, 0.110 – 0.655 and 2.058 – 10.063 μg/g for As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn respectively while in the goat meat samples the concentration of the minerals ranged from 0.137 – 0.801, 0.299 – 0.853, 0.356 – 0.882, 0.255 – 0.861, 0.779 – 2.039, 18.099 – 28.765, 3.234 – 4.922, 0.839 – 1.013, 0.130 – 0.896 and 3.552 – 9.961 for unwashed goat meat and 0.117 – 0.799, 0.219 – 0.875, 0.296 – 0.771, 0.215 – 0.751, 0.674 – 2.002, 19.099 – 30.065, 3.034 – 4.221, 0.631 – 1.001, 0.110 – 0.799 and 3.652 – 9.061 μg/g in washed goat meat samples for As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn, respectively.

All the minerals determined in the meat samples (As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) were detected in all the meat samples bought from various slaughter places in the study areas in various concentrations. The qualitative similarity of the minerals in the meat samples is an indication that the materials for singed and processing of the meats used in the slaughter places in the study areas are really the same or similar in all the areas the meat samples were collected for the analysis. Because of the complicated pattern in the concentration relationship of the samples, focusing on the comparison between the different meat products will be futile; instead, the general profile of each mineral will be discussed focusing attention to any anomaly. The little discrepancies in the differing quantitative pattern among the samples were expected but these differences were not significant (p>0.05). Therefore follows from results (Tables 1, 2 and 3), the presence of elements like As, Cd, Cr, Ni, and Pb indicated that some of these meat products singed with scrap tyres and plastic wastes could be carcinogenic (Tong *et al.,* 2000). The carcinogenicity nature from observation has no correlation from the areas the meat samples were collected from but the processing method (Odoh*et al.,* 2015), even though minerals present in these meat products do not entirely determine the risk likely to be caused by meat consumptions, they can become more hazardous where they are present in higher concentrations, and could lead to higher health risk. Special attention has been given to the elements that play a significant toxicological role after entering the human body through these meats consumption or uses of meat products. Contamination of these meats with some of these minerals could pose potential health risk to humans and animals because some of these minerals have the ability to "bio-accumulate". Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Reports from previous research have shown that compounds accumulate in living things any time they are taken up and stored faster than they are broken (metabolized or excreted) (Tong *et al.,* 2000; Poulsen, 1998). For instance, research has shown that significant flux of minerals, among other toxins, reach the lungs through the consumption of contaminated foods, either meats or uses of meat products (Odoh*et al.,* 2015).

All the meat samples studied contained detectable amounts of these minerals of interest in various degrees. Arsenic concentration varied between 0.117 and 0.999 µg/g for unwashed and washed meat samples while it was not detected in the control meat samples analyzed from the study areas. The presence of this metal in the meat samples may due to materials used to singe these meats. Arsenic is highly carcinogenic has no nutritional value for plant and animal (Amadi*et al.,* 2012). The highest arsenic concentration (0.695±0.011 µg/g) was observed in the unwashed beefs and the lowest value (0.443±0.042 µg/g) was found in washed goat meat. Higher concentration of arsenic in beefs (cow meats) and caprice (goat meats) has also been reported by Krupa and Swida (1997). The permissible limit of arsenic in the livers of chickens has been reported as 2.000 µg/g and it was found that the highest concentration of arsenic recorded in this research (0.595±0.011 µg/g) was lower than the permissible limit.

The concentration of cadmium ranged from 0.209 – 0.953 µg/g for both unwashed and washed meats analyzed from the study areas, while in the control samples, the same metals was not detected. Cadmium is toxic to virtually every system in the body. Cadmium accumulated in the meats over time have been reported by McLaughlin *et al*. (1999) that cadmium interacts with a number of minerals mainly Zn, Fe, Cu and Se due to chemical similarities and competition for binding stage. It is also reported that Cd can affect Ca, P and bone metabolism of people exposed to Cd contamination in the environment (Jarup*et al*., 1998). High Cadmium levels has been detected in the cow meats in some industrial countries and the cadmium concentration found to be above the permissible limit set by FAO/WHO, 2000, (Aranha 1994; Roga-Franc *et al*., 1996). Similarly, Doganoc (1996) found higher levels of cadmium and zinc in the meats of the hens and chickens, which exceeded the official tolerance levels. From the results of this study, the concentration of cadmium in some of the meat samples studied were found to be higher than the 0.500 µg/g permissible limit set by (FAO/WHO, 2000).

Cobalt concentration ranged 0.257 – 0.987 µg/g for both unwashed and washed meat samples from the study areas. The measured concentrations of Co are unacceptable range for uncontaminated meat materials. Cobalt is widely used as alloys for steels, electroplating, fertilizer, porcelain and glass making. It is essential for the growth of algae and bacteria and required in trace concentration for higher plants and animals (Mielke, 1994; Rayment& Higginson, 1992; Aboud&Nandini, 2009; Amadi*et al*., 2012).

The concentrations of Chromium (Cr) were observed in unwashed and washed meat samples from the study areas are as presented in Table 1, 2 and 3. The highest concentration of Cr was found in the unwashed cow meat (0.967µg/g) and the lowest level was observed in meat of washed goat meats (0.215 µg/g). Cr is an essential element helping the body to use sugar, protein and fat, at the same time it is carcinogenic for organisms (Institute of Medicine, 2002). Excessive amounts of Cr may cause adverse health effects (ATSDR, 2004).The concentrations this metal of all the meat samples from the study areas recorded were higher than the permissible limit of 0.10 µg/g.

Table 3: Range and average levels of minerals (µg/g) in unwashed and washed goat meats (Caprine) singed with scrap tyres and plastic wastes

Elements	Unwashed meat		Washed meat	
	Range	**Mean±SD**	**Range**	**Mean±SD**
As	0.137 – 0.801	0.591±0.021	0.117 – 0.799	0.499±0.045
Cd	0.299 – 0.853	0.551±0.016	0.219 – 0.875	0.459±0.012
Co	0.356 – 0.882	0.698±0.017	0.296 – 0.772	0.532±0.024
Cr	0.255 – 0.861	0.806±0.022	0.215 – 0.751	0.509±0.072
Cu	0.779 – 2.039	1.787±0.786	0.674 – 2.002	1.681±0.484
Fe	18.099 – 28.765	23.119±0.925	19.099 – 30.065	23.912±0.324
Mn	3.234 – 4.922	3.511±0.098	3.034 – 4.221	3.111±0.017
Ni	0.839 – 1.013	0.896±0.111	0.631 – 1.001	0.776±0.221
Pb	0.130 – 0.896	0.493±0.013	0.110 – 0.799	0.413±0.033
Zn	3.552 – 9.961	7.931±0.114	3.652 – 9.061	7.839±0.105

The concentration of copper in unwashed and washed meat samples ranged from 0.674 – 2.231 µg/g. The highest copper concentration was found in the cow and sheep meats (1.987±0.987 and 1.987±0.281 µg/g) and the least value was observed in the meat of goat meats (1.681±0.484 µg/g). The copper concentration in the both unwashed and washed meat samples was below the permissible limit of 200µg/g FAO/WHO (2000),Mukhacheva and Bezel (1995) found higher levels of copper and zinc in the mutton and beef. Copper is an essential component of various enzymes and it plays a key role in bone formation, skeletal mineralization and in maintaining the integrity of the connective tissues. Copper is essential for good health, but very high intake can cause health problems such as liver and kidney damage (ATSDR, 2004). Copper can also cause public health hazards in high concentrations (Brito*et al.*, 2005). In humans, 10-30 mg of orally ingested copper from foods stored in copper vessels might cause intestinal discomfort, dizziness and headaches, while excess accumulation of copper in liver may result in hepatitis or cirrhosis and in a haemolytic crisis similar to that seen in acute copper poisoning (Johnson, 1993).

The concentration of iron in all the samples from the study areas ranged from 16.334 – 30.065 µg/g for both unwashed and washed meat. The results indicate that the washed goat meats (mutton) (23.912±0.324 µg/g) contained the highest concentration of Fe, followed by washed sheep meats (caprine) (23.623±0.325 µg/g). The beef meat showed the least concentration (22.123±1.225 µg/g).

The concentration of Mn in the meat samples from the study areas ranged from 2.034 – 4.922 µg/g for unwashed and washed meat samples. Daily intake of small amounts of Mn is needed for growth and good health in humans, otherwise deficiency of Mn can cause nervous system problems (Demirezen and Uruç, 2006). It was observed that the unwashed goat meats showed the highest Mn concentration of 3.511±0.098 µg/g and the lowest concentration of 2.113±0.111 µg/g was observed for sheep meat.

Table 4: Range and average levels of minerals (µg/g) in control meat samples from the study areas

Elements	Cow meat		Sheep meat		Goat meat	
	Range	Mean±SD	Range	Mean±SD	Range	Mean±SD
As	N.D	N.D	N.D	N.D	N.D	N.D
Cd	N.D	N.D	N.D	N.D	N.D	N.D
Co	0.001–0.012	0.018±0.017	0.096–0.172	0.012±0.024	0.057–0.188	0.134±0.021
Cr	N.D	N.D	N.D	N.D	N.D	N.D
Cu	0.079–0.239	0.387±0.086	0.074–0.102	0.481±0.083	0.087–0.435	0.17±0.081
Fe	10.023–15.261	13.102±0.224	9.092–16.024	11.212±0.114	8.052–17.262	9.121±0.321
Mn	1.231–2.022	1.011±0.011	1.032–2.023	1.011±0.012	1.032–2.001	1.014±0.011
Ni	N.D	N.D	N.D	N.D	N.D	N.D
Pb	N.D	N.D	N.D	N.D	N.D	N.D
Zn	2.553–5.921	4.231±0.104	1.652–7.062	3.519±0.002	2.413–5.362	3.214±0.003

The concentrations of nickel (Ni) in the meat samples from the study areas (unwashed and washed meats) beef, mutton and caprine ranged between 0.692±0.121 and .0997±0.123 µg/g. The levels of Ni ranged between 0.631 and 1.097 µg/g for beef meat, mutton meat and caprine meat, respectively as shown in Tables 1, 2 and 3. The highest Ni concentration was observed in unwashed cow meats (beef), while lowest value (0.631 µg/g) was found in the mutton meat.

The concentration of lead in all the meat samples studied ranged from 0.110 – 0.896 µg/g. Lead as observed in the cow meats (beef) showed the highest concentration of 0.543±0.024 µg/g, similar results obtained by Siedenburg *et al*. (1988) who determined lead concentrations in liver and kidney of cattle within a 20 km radius of zinc refineries and compared these with cattle in unpolluted control areas.

Significantly higher amounts of lead were found in all the meats sampled from the study areas. Aranha (1994) reported higher concentration of lead than the permissible limit in the liver and kidney of animals. Danev*et al*. (1996) showed that 86% samples of liver and 100% samples of kidney were contaminated above the limits set by the country's regulations. Similarly, Maldonado *et al.* (1996) studied lead with reference to its intestinal absorption, mobilization and redistribution during lactation in rats and showed significantly higher levels of lead in the livers and kidneys. The results revealed that the concentrations of lead in the meat of beef, mutton and caprice were higher and show higher contamination since the metal were not detected in the controlled meat samples thus indicating high contamination of the meats collected from the study areas.

The concentration of zinc in all the meat samples from the study areas ranged from 2.058 – 10.765'. Zinc concentration was found to be highest in the sheep meat (mutton) (10.765 µg/g). Zinc is an essential element in human diet. Too little Zn can cause problems; however, too much Zn is harmful to human health (ATSDR, 2004). The concentrations of zinc in all the samples studied were below the permissible limit 150 µg/g set by FAO/WHO.

Conclusion

From the analysis, it was realized that meat processed or singed with scrap tyres and plastic wastes contains some toxic metals (arsenic, cadmium, nickel and lead) which were introduced into the meats from scrap tyres and plastic wastes. The uses scrap tyres and plastic materials are the highest contributors of these toxic metals to singed meats. The sources of these minerals in these materials are linked to the composition of the raw materials from which the items were derived from. Hence, the uses of scrap tyres and plastic wastes should look inward to and possibly stop in order to ensure that they produced meat products that are free from toxic minerals. It was also observed that The concentrations of some the minerals like Fe, Cd, Cr, Cu and Zn exhibited some pattern where the unwashed singed meat showed lower concentration, increased after washing with the water. This implies that the water used for washing the meat probably contributed to the level of these minerals in the meat.

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