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DEPARTMENT OF ENVIRONMENTAL SCIENCE

COMPARATIVE ASSESSMENT OF HEAVY METAL LEVELS IN ANIMAL HIDE SINGED WITH MOTOR VEHICLE SCRAP TYRES AND LIQUEFIED PETROLEUM GAS (LPG) AS SOURCE OF FUEL

BY

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DECLARATION

The study was undertaken entirely by me under the guidance of my supervisor. Where references to the work of others have been made, this has duly been acknowledged. I do declare that this thesis has not been submitted for a degree to any other University.

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DEDICATION

To my dear parents Mr and Mrs Sunu and my siblings Grace and Abigail

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ABSTRACT

The present study was undertaken to assess the presence and levels of heavy metal contamination (Mg, Mn, Cu, Ni, Zn, Cd and Pb) in goat and sheep hides singed with vehicle scrap tyres or Liquefied Petroleum Gas (LPG) as fuel, using atomic absorption spectrometry. For assessment of contamination, thirty six goat and sheep hide samples from three slaughter points recognized by the Accra Metropolitan Assembly were analyzed. Goat and Sheep hides singed with LPG resulted in some increases in Mg, Zn and Ni, as well as decreases in Mn and Cu levels, however, singeing with vehicle scrap tyres, resulted in elevated concentrations in heavy metals analyzed in both goat and sheep hides. In goat hides, the highest levels of increases by 128%, 26.3%, 105.66%, 37.73% and 14.17% in Mn, Mg, Cu, Zn and Ni from 6.45±0.55mg/kg, 528.35±62.95mg/kg, 5.3±0.8mg/kg, 226.9±56.9mg/kg and 12±1.8mg/kg respectively, to 14.75±2.45mg/kg, 667.35±56.35mg/kg, 10.9±2.7mg/kg, 312.5±22.5mg/kg, and 13.7±1.5mg/kg, respectively were observed when singed with vehicle scrap tyres as fuel. In sheep hides, the highest levels of increases by 57%, 43.53%, 142.25%, 135.21% and 50.42% respectively, in Mn, Mg, Cu, Zn and Ni from 3.55±1.05mg/kg, 482.85±57.35mg/kg, 3.55±0.95mg/kg, and 126.8±43mg/kg and 11.8±0.9 mg/kg to 5.6±1.9mg/kg, 693.05±45.85mg/kg, 8.6±3.1mg/kg, 298.25±26.75mg/kg and 17.75±4.75mg/kg respectively were observed when singed with vehicle scrap tyres as fuel source. Pb and Cd were not detected in any of the samples but Zn levels in all fresh unsinged goat and sheep hides analyzed were already above the Maximum Permissible Limit of 50.0 mg/kg set by the European Commission Regulation and the United States Department of Agriculture. This could be attributed to the prevailing animal rearing and environmental conditions such as soil, pasture, water sources and medication.

It was concluded that vehicle scrap tyre singed hides were potentially unsafe for human consumption even though questionnaire survey of butchers revealed that hides singed this way were sold in most major markets in the Accra Metropolis and consumers were not able to tell whether they were buying meat that had been singed with LPG or vehicle scrap tyres as fuel.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Meat is a food material, which is composed mainly of proteins, fat and some important essential elements and is necessary for growth and maintenance of good health. Slaughtered ruminants such as goats, sheep and cattle for meat are normally singed to get rid of the fur. Singeing is largely favoured in many respects in African countries as it maintains the carcass hide for consumption and evokes flavours in meat that are highly acceptable by the local populace (FAO, 1985).

Traditionally, singeing proceeds in open fire using firewood as fuel, but the relative scarcity of firewood lately has resulted in local butchers using scrap tyres as alternative source of fuel to singe slaughtered livestock. The practice, though unconventional and potentially dangerous, is increasingly favoured by local butchers; reasons being that fire from the scrap tyres is able to selectively burn off the animal fur without cracking the hide. Many local butchers in Ghana have been using scrap tyres as substitute for firewood to singe slaughtered ruminants (Obiri-Danso *et al.*, 2008). The burning of the hide is done under uncontrolled fires (*i.e.*, open fires, not regulated) and lacks legislative measures, which is typical for poor households in developing countries such as Ghana. There is also the possibility of a catastrophic fire occurring because of the large quantities of petroleum and other chemicals in tires. A burning tire creates thick, black, toxic smoke as well as large discharges of environmental pollutants (Essumang *et al.*, 2007).

In view of the fact that tyres contain many potentially harmful substances (USFA, 1999), singed treatment with scrap tyres imposes enormous risk of deposition of toxic elements and compounds into the animal hide, which could significantly compromise meat quality.

The risk of heavy metal contamination in meat therefore 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; Mahaffey, 1977). In this case, continuous consumption of such potentially contaminated meat product poses a great source of health risk (Costa, 2000; Jayasekara *et al.*, 1992; Leita *et al.*, 1991).The environmental pollution caused by the burning of tyres is a matter of great concern worldwide, and consequently contamination of the food chain is getting increasingly important in view of its role in human health and nutrition.

Another important reason causing contamination of meat is the deposition of contaminants from vehicle emission and from the dirty slaughter places and there is the necessity to establish ongoing knowledge of various pollutants in the meat. Most meat shopkeepers sell most of the meat in the open market and even at road sides (Sabir *et al*., 2003) and the location of some slaughter points also exposes meat produced from them to vehicle emissions and other pollutants into the environment. It is against this background that the present study investigated local singeing practices in the Accra Metropolis with respect to the use of scrap tyres and LPG gas to singe slaughtered ruminants at specific slaughter points. The singeing practice was assessed as a potential source of heavy metal contamination in goats and sheep hides consumed locally in Ghana.

1.2 Problem Statement

Statistics provided by MOFA (2009), suggest a total of 101,895 tons of domestic meat production in Ghana with poultry contributing 31.6%, sheep and goats 32.9% and cattle 19.2%.

While meat consumption has been relatively static in the developed world, annual per capita consumption of meat has doubled since 1960 in developing countries. Meat consumption in developing countries has been continuously increasing from a modest average annual per capita consumption of 10 kg in the 1960s to 26 kg in 2000 and will reach 37 kg around the year 2030 according to FAO projections (FAO, 2007). Growing population and incomes, along with changing food preferences are increasing the demand for livestock products (FAO, 2012).

In Ghana, singeing practices predominantly used in the processing of slaughtered livestock include, the use of fire fueled by scrap tyres or LPG gas to remove animal fur. Owing to the high cost and inadequate supply of LPG, most butchers have resorted to the use of burning scrap tyres for singeing which has serious environmental and health implications. Tyre-singeing leads to the accumulation of heavy metals in meat which poses health risks when eaten. In a study carried out in Ghana (Obiri-Danso *et al.*, 2008), the levels of heavy metals in the singed animal hides were generally high compared to the levels in some other meat products in India and the Slovak Republic (Santhi *et al.,* 2008; Korenekova *et al*., 2002). Another report (Essumang *et al.,* 2007), attributed heavy metals in cattle hides (wele) in Ghana to tyre-singed treatments and reported elevated levels for iron, zinc, chromium and nickel respectively in singed hides processed with vehicle worn-out tyres.

Due to their non-biodegradable and persistent nature, heavy metals are accumulated in vital organs in the human body such as the kidneys, bones and liver and are associated with numerous serious health disorders (Duruibe *et al.,* 2007). Individual metals exhibit specific signs of their toxicity. Persistent over-indulgence in taking magnesium supplements can lead to muscle weakness, lethargy and confusion (Lenntech, 2012).

Lead, Zinc, Copper and Aluminium poisoning have been implicated with gastrointestinal (GI) disorders, diarrhoea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to urine, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia (McCluggage, 1991). Hauser *et al.*, (2009) reported that high doses of cadmium can lead to kidney failure, damage to testicles and liver. Adverse Manganese effects occur in the respiratory tract and in the brain as well. Some symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage. Manganese poisoning can also cause Parkinson's disease, lung embolism and bronchitis (Santamaria, 2008).

An uptake of too large quantities of nickel leads to higher chances of development of lung, nose, larynx and prostate cancer, lung embolism, respiratory failure, birth defects, asthma, chronic bronchitis and heart disorders (Lenntech, 2012).The nature of effects can be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic (European Union, 2002).

In Ghana, irrespective of the Food and Drugs Law, 1992 (P.N.D.C.L. 305B) which provides guidelines for the regulation of livestock products and also the presence of bye-laws in all Metropolitan, Municipal and District Assemblies to govern the production of meat in their respective slaughter houses, unhealthy practices such as animal singeing using vehicle scrap tyres, is still being exploited as a meat processing technique.

The present study sought to determine and compare the levels of some heavy metals in meat singed with burning vehicle scrap tyres as source of fuel and that singed with Liquefied Petroleum Gas. Primary sales points of meat singed with vehicle scrap tyres to consumers would also be determined.

1.3 Aim and Objectives of the Study

The aim of the present study was therefore to determine and compare heavy metal concentrations in meat from goat and sheep livestock singed, using as fuel vehicle scrap tyres and liquefied petroleum gas (LPG).

Specifically, the study aims at achieving the following objectives

1. Determining the motivation for unconventional meat production.
2. Determining the presence and concentration of heavy metals (Mg, Mn, Cu, Ni, Cd, Pb and Zn) in meat samples obtained from some selected slaughter points in the Accra Metropolis.
3. Identify the primary sales points of meat from one of the main slaughter points where singeing of animals is done using vehicle scrap tyres as fuel.

1.4 Scope of the Study

Three slaughter points were selected based on their recognition by the Accra Metropolitan Assembly as animal slaughter points, namely; the Jamestown slaughter point, Avenor slaughter point and the Accra Abattoir. From the three slaughter points selected, thirty six samples of goat and sheep hides would be collected, twelve from each slaughter points selected and would be analyzed for the presence and concentration of Magnesium (Mg), Cadmium (Cd), Lead (Pb), Copper (Cu), Zinc (Zn), Nickel (Ni), and Manganese (Mn) using Atomic Absorption Spectrometry.

Meat processors would also be interviewed about slaughter practices and points where processed meat was sold and reasons for type of fuel chosen for singeing of animal fur during meat processing.

Jamestown slaughter point, in the Accra Metropolitan area slaughters numbers of goats and sheep on a daily basis to meet consumer demands. The scrap tyre method of singeing is used in processing the hides of slaughtered animals. Jamestown is one of the oldest districts in the city of Accra and has the Jamestown Fort and Jamestown Lighthouse as well known tourist sites; along the coast of Jamestown where slaughtered animals are singed using burning vehicle scrap tyres and washed with the sea water into which all meat processing effluent flows.

The other slaughter point in Accra under the supervision of the Accra Metropolitan Assembly is the Avenor Slaughter point. The Avenor slaughter point adopted the use of LPG with burners in processing slaughtered goats and sheep for consumers but occasionally uses scrap tyres for singeing during gas shortages or when they have to meet large orders.

The third slaughter point is the Accra Abattoir just on the outskirts of the Accra Metropolis. The Accra Abattoir has state of the art facilities and is sited off the Tema motorway just before the Ashaiman overhead and singeing is done with LPG in a singeing plant.

1.5 Justification of the Study

Singeing with scrap tyres poses a health challenge as well as an environmental hazard. This deserves not only the attention of the Metropolitan Assembly and the Environmental protection institutions but also concerns of Health institutions and individuals to find a lasting solution to the problem. This is because, vital human resource could be lost through poor health associated with its effects and environmental pollution. The present study, therefore intended to investigate the levels of heavy metal (accumulation) in scrap tyre-singed meat compared to that singed with LPG, and the points of sales to unsuspecting consumers.

Despite the immensity of the problem, other unauthorized slaughter sites are springing up around the metropolis that use scrap tyres including those recognized by the AMA.

The results of the present study would therefore contribute to the understanding of the danger to health posed by the use of vehicle scrap tyres for singeing and reasons why the use of LPG is not being adopted.

Additionally, the study would contribute to existing body of knowledge on heavy metal accumulation in food and also stimulate further research on the subject.

1.6 Limitations of the Study

Obtaining samples for laboratory analysis and taking of photographs of the sites was difficult as butchers felt that these could be used as evidence to put an end to their livelihood.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Importance of meat

The protein requirement of man may be obtained from either animal or plant sources. The contribution of livestock to food supplies in developing countries is increasing at a higher rate than that of cereals (FAO, 1994a). Meat is the common term used to describe the edible portion of animal tissues and any processed or manufactured products prepared from these tissues. Meats are often classified by the type of animal from which they are taken (Encyclopedia B, 2012). Animal protein contains the essential amino acids tryptophan and lysine, which plants lack. Fat of meat also contain the essential fatty acid, linoleicic acid that plants lack. For these reasons, animal proteins have got a greater biological value than proteins of plant origin (Forest *et al*., 1975; Warris, 2000). The three major sources of animal protein in Ghana are from domesticated farm animals, game and fish. Out of the domesticated farm animals, cattle, sheep, goats, pigs and chicken are the usual animals that are slaughtered in Ghana.

Statistics provided by MOFA (2009), suggested a total of 101,895 tons of domestic meat production in Ghana with poultry contributing 31.6%, sheep and goats 32.9% and cattle 19.2%.

The red meat of sheep and goats have the widest distribution in most areas of the developing tropics because of the prolific nature, hardiness in adverse conditions and, most importantly, their high rate of acceptability with the vast majority of people (FAO, 1985).

Together with fish, livestock food products provide essential amino acids, minerals and vitamins in a concentrated form, and their fat content can also supply much needed calories.

Due to its rich composition and therefore its great value as supplement, meat is very important in the nutrition of the most sensitive groups of population: pregnant women, lactating mothers, children and elderly. For adequate nutrition, a person's daily protein intake should be 1 g per kilogram of body weight. In developed countries this is easily reached and, in most cases, exceeded, while in developing countries there is a widespread deficit. Ideally, 30 to 50 percent of the daily protein intake should be animal protein, particularly in developing countries, since this provides an optimal range of amino acids. The average intake of animal protein in developing countries, however, is as low as 15 g per person per day (10 g from meat and 5 g from milk), compared with almost 60 g in developed countries. The contribution of livestock to food supplies in developing countries is increasing at a higher rate than that of cereals while in developed countries a certain saturation and decrease in the overall consumption of livestock products can be seen. The demand for livestock products will continue to rise in developing countries as a result of their rapidly expanding populations and the tendency towards higher incomes in most of these countries (FAO, 1995).

2.2 General principles of meat hygiene

Meat must be safe and suitable for human consumption and all interested parties including government, industry and consumers have a role in achieving this outcome. The competent authorities should have the legal power to set and enforce regulatory meat hygiene requirements, and have final responsibility for verifying that regulatory meat hygiene requirements are met in all countries. It should be the responsibility of the establishment operator to produce meat that is safe and suitable in accordance with regulatory meat hygiene requirements.

In addition, there should be a legal obligation on relevant parties to provide any information and assistance as may be required by the competent authority (FAO, 2004).

Meat hygiene programmes should have as their primary goal the protection of public health and should be based on a scientific evaluation of meat-borne risks to human health and take into account all relevant food safety hazards, as identified by research, monitoring and other relevant activities. Meat hygiene requirements should control hazards to the greatest extent practicable throughout the entire food chain. Information available from primary production should be taken into account so as to tailor meat hygiene requirements to the spectrum and prevalence of hazards in the animal population from which the meat is sourced.

The range of activities involved in meat hygiene should be carried out by personnel with the appropriate training, knowledge, skills and ability as defined by the competent authority. The competent authority should verify that the establishment operator has adequate systems in place to trace and withdraw unwholesome meat from the food chain. Communication with consumers and other interested parties should be considered and undertaken where appropriate (FAO, 2004).

The demand for cheap meat, therefore, is as integral to the problem as the supply of potentially unsafe meat (Daluiso, 2012). In the developed countries, there exist strict legal regulations on the hygienic standards of handling and processing of meat. In most developing countries especially in rural commuinities standard and hygienic methods of handling and processing meat are given far less attention even though they are or form part of the country’s rules and regulations on animals and meat production.

For example in most rural areas in Ghana perhaps due to certain constraints such as the absence of potable water, unavailability of reliable of power (electricity) supply, meat processing is traditionally carried out in unhygyienic conditions. Slaughter methods are sometimes dictated by religious beliefs, and local customs without inspection by a qualified veterinary officer (Adzitey *et al.,* 2011). One of the main constraints in the improvement of hygiene and the technical quality of slaughtering, meat handling and by-product utilization is the lack of adequately trained personnel at all levels (FAO, 1995).

2.3 Slaughtering Practices and Consumer Perception

Slaughter methods prevailing throughout the world are governed either by tradition, ritual or legislation depending upon the people and the country. In essence, methods are determined by the manner in which the animal is killed and bled and to some extent dressed and handled prior to use as food (FAO, 1985). Traditional slaughtering is fairly common in the rural areas and villages of the developing world and also in Ghana.

According to Aberle *et al.*, (2001) the present day manufacture of processed meat products is driven largely by consumer demand for safety, convenience, unique flavour, distinctive product forms and imaginative packaging. This gives the consumer the opportunity in determining what he/she wants and hence his/her money's worth. With increasing meat consumption, consumers are keen to have a greater variety of meat preparations at their disposal, a demand that can be met by offering various types of processed meat (FAO, 2007).

Slaughtered ruminants such as goats, sheep and cattle are normally singed to get rid of the hair as a processing technique.

The presence of hair and not wool, makes singeing and scraping of the skin in tropical sheep easier, for instance, easier. The process is largely preferred in many respects in African countries as it naturally increases carcass yield, and evokes flavours highly acceptable to the cultures that use this practice (FAO, 1985). Flavour is the most important factor in our food choices (Pearson and Gillett, 1999). Consumers usually use flavour as a quality attribute to determine the acceptability of meat. Both taste and odour contribute to flavour, and it is generally difficult to distinguish between the two as they are normally evaluated together for a reliable determination of a product's flavour during consumption (Adegoke and Faladay, 2005).

2.4 Singeing of slaughtered ruminants

Singeing is done because it removes hairs off the animal, reduces the number of adhering micro-organisms, shrinks and sets the skin and leaves an attractive clean appearance. It can be done with a hand-held gas torch, or automated systems can be used to transport the slaughtered animals into a furnace and give it ample time for an effective singe. Black deposits on hides and singed hairs are scraped off, and the carcass is cleaned thoroughly before evisceration begins (FAO, 1991).

Traditionally, singeing is done in open fire fueled with firewood, but local butchers have resorted to the use of scrap tyres as alternative source of fuel to singe slaughtered livestock due to the relative scarcity of firewood in recent times. Local butchers prefer the practice, though unconventional and potentially dangerous, because fire from the scrap tyres is able to selectively burn off the animal fur without cracking the hide (Obiri-Danso *et al*., 2008).

Singed treatment with scrap tyres imposes enormous risk of deposition of toxic elements and compounds into the animal hide, which could significantly compromise meat quality as tyres contain many potentially harmful substances (USFA, 1999). In this case, continuous consumption of such potentially contaminated meat product poses a great source of health risk (Costa, 2000; Jayasekara et al., 1992; Leita et al., 1991)

Other methods have been introduced and adopted by several meat processors in the last few decades. Such methods include singeing off the hair in flames fuelled by various substances such as wood mixed with spent engine oil, plastics mixed with refuse or tyres. These materials contain toxic substances which can contaminate the hides and render them unfit for human consumption (Okiei *et al.*, 2009).

In Ghana treated cattle hide known as "wele" is one of the most well-patronized meat products in Ghana. It is prepared for consumption by burning the fresh hide in a naked sooty flame of worn-out lorry tyres (Essumang *et al*., 2007; Obiri-Danso *et al*., 2008). The burning of the hide is done under uncontrolled fires (*i.e.,* open fires, not regulated) despite the fact that some legislation state otherwise. In Accra, AMA (Slaughter House/ Slab) Bye – laws, 2007 governing meat production states under paragraph 7 that; No such body/ butcher /marketer as licensed shall singe hides of carcasses using lorry tyres and any person who contravenes any provision of these Bye-laws commits an offence and is liable on conviction to a fine or to imprisonment to a term not exceeding three months or to both.

Tyres also contain several metals such as lead, mercury, cadmium, chromium, zinc and arsenic which can contaminate hides when burnt tyres are used as a source of fuel (IAFC, 2000; Pechan and Associates, 1997; OECD, 2004). All involved in the processing are also at risk because of the associated health hazards through inhalation of these toxic compounds (Okiei *et al.*, 2009).

2.5 Composition of rubber tyre

Tyres are composed of vulcanised rubber in addition to the rubberised fabric with reinforcing textile cords, carbon black, steel or fabric belts and steel wire reinforcing beads. A number of different natural and synthetic rubbers and rubber formulation are used to produce tyres (Bajus *et al.*, 2011). Approximately 80% of the weight of car tyres and 75% of truck tyres is rubber compound (STMC, 2012). Chemical analysis revealed that metals such as Zn, Fe, Mg, Ni and Ca can be present in different concentrations, depending on the type of bracing used, the degree of wear and the type of tyre (car or lorry) (Warner *et al.*, 2002).

According to the Basel Convention 1999, Technical Guidelines on the Identification and Management of Used Tyres, tyres contain a total of approximately 1.5% by weight of hazardous waste compounds listed in Annex 1 of the Basel Convention. These compounds, outlined in Table 1, are encased in the rubber compound or present as an alloying element.

Table 1: Metal composition of tyres

Chemical Name	Content (%Weight)
Copper Compounds	Approx 0.02%
Zinc Compounds	Approx 1%
Cadmium	Max 0.001%
Lead and Lead compounds	Max 0.005%
Acids in Solid form	Approx 0.3%
Organohalogen compounds	Max 0.10%

The durability and immunity of the above material to biological degradation makes their disposal and reprocessing difficult (Bhatt *et al.*, 2012).

2.6 Air Emissions from Scrap Tyre Combustion

Air emissions from open tyre fires have been shown to be hazardous regardless of how burning is done. Open tire fire emissions include “criteria” pollutants, (i.e air pollutants that have been regulated and are used as indicators of air quality) such as carbon monoxide (CO), sulfur oxides (SOx), particulates, oxides of nitrogen (NOx), and volatile organic compounds (VOCs). “Non-criteria” hazardous air pollutants (HAPs), (i.e all other air pollutants apart from the criteria pollutants), such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs), arsenic, cadmium, nickel, zinc, mercury, chromium, and vanadium are also included. Tyres contain around 20 different metals, which cannot be destroyed by burning them, since they are elements.

Metals known to be in tyres include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silicon, tin, titanium and zinc (USEPA, 1997).

“Dioxins” refer to a group of persistent, very toxic chemicals including, polychlorinated dibenzo-p-dioxins (PCDD’s), furans and some polychlorinated biphenyls (PCBs) which share certain chemical structures and biological characteristics (Cook and Kemm, 2004). Certain metals found in tyres (such as copper, iron, manganese, nickel, sodium and zinc) serve as catalysts for the formation of dioxins, by providing a surface on which dioxins can readily form during and after the combustion process, (OECD, 2003).

PAH's emissions from an open tyre fire can present significant acute (short-term) and chronic (long-term) health hazards to all involved and nearby residents.

Depending on the length and degree of exposure, these health effects could include irritation of the skin, eyes, and mucous membranes, respiratory effects, central nervous system depression, and cancer (USEPA, 1997). This report also indicated that uncontrolled tyre fires usually have major environmental impacts, which include air pollution, water pollution and soil pollution.

2.6.1 Air pollution

Black smoke and other substances such as volatile organic compounds, dioxins and polycyclic aromatic hydrocarbons are released into the atmosphere.

2.6.2 Water pollution

The intense heat allows pyrolysis of the rubber to occur, resulting in an oily decomposition product which is manifested as an oil runoff. The average passenger car tyre is estimated to produce more than two gallons of oil when burned (Rubber Manufacturers Association, 2003). Oil produced seep into ground and surface water and other combustion residues (such as zinc, cadmium and lead) can also be carried by water off the site.

2.6.3 Soil pollution

Residues that remain on the site after the fire can cause two types of pollution; these are immediate pollution by liquid decomposition products penetrating soil, and gradual pollution from leaching of ash and unburned residues following rainfall or other water entry.

2.7 Heavy Metals

Heavy metals are an inexact term used to describe more than a dozen elements that are metals or metalloids. Heavy metals have densities above 5g / cm3. They cannot be destroyed or degraded. Heavy metals are persistent in all parts of the environment. Human activity affects the natural geological and biological redistribution of heavy metals through pollution of air, water and soil.

Pollution due to heavy metals is a global threat to the environment as they occur naturally in earth"s crust and are present in all ecosystems in varying concentrations. Heavy or toxic metals with a density of at least five times that of water cannot be degraded or destroyed and therefore bioaccumulate in biological systems (Farr, 2004). The primary sources of these pollutants are garbage's, trash, raw sewage, chemical effluents of the industries and emission of irritant and harmful gases from various sources. These pollutants emerge from rapid population growth, massive urbanization and extensive industrialization throughout the world (Raja *et al*., 1996).

The primary anthropogenic sources of heavy metals are point sources such as mines, coal-burning power plants and vehicle emissions. There are 35 metals that are a concern to us because of occupational or residential exposure; 23 of these are the heavy metals: antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium and zinc (Glanze,1996).

Interestingly, small amounts of these elements are common in our environment. Some of these known as trace elements, (e.g. iron, copper, manganese and zinc) in small quantities are nutritionally essential for a healthy life.

These elements, or some form of them are commonly found in foodstuffs, in fruits and vegetables, and in commercially available multivitamin products (International Occupational Safety and Health Information Centre, 1999).

Many elements are useful to life, for example iron as oxygen carrier in hemoglobin, calcium and phosphorus in bone building and magnesium in chlorophyll. However, with their increased concentration in the environment, they are toxic, retard growth and ultimately cause the death of living organisms. Contamination of the environment with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnification in the food chain (Demirezen and Uruc, 2006).

The environmental pollution with heavy metals is a matter of great concern worldwide and its consequent contamination of food chain is getting more and more important in view of the adverse effect on human health and nutrition (Khan *et al*., 1995).

2.7.1 Exposure pathways of heavy metals in the environment

According to Tayab, (1991) man's activities have disturbed the natural distribution of heavy metals in the environment (land, rivers, lakes and seas). Emissions of heavy metals into the environment occur *via* a wide range of processes and pathways, e.g. into the air (*e.g.* during combustion, extraction and processing), into surface waters (*via* runoff and releases from storage and transport) and into the soil (and hence into groundwater and crops). People may be exposed to potentially harmful chemical, physical and biological agents in air, food, water or soil, however; exposure does not result only from the presence of a harmful agent in the environment.

The key word in the definition of exposure is contact. There must be contact between the agent and the outer boundary of the human body, such as the airways, the skin or the mouth (Järup, 2003). Over the last few years, the problem of pollution by heavy metals has caused increasing concern. This applies to both industrialized zones and highly technological, populated areas even though in different ways.

Therefore, the problem of pollution from heavy metals involves the whole population and regards all three receiving compartments air, water and soil. In Africa in the last decade, increases in both industrial activities and urbanisation have led to huge increases in the amount of various wastes (solid, liquid and gaseous emissions) including heavy metals inputs into the environment in all parts of the continent. Other sources in the region which contaminate the environment with large amounts of toxic metals include activities such as leather tanning, electroplating, emissions from vehicular traffic, gas exhausts, crude oil and hydrocarbon exploration and exploitation energy and fuel production (Alo *et al.*,2006).

The principal metal emission processes come from the following industries; petrochemical, extractive, metallurgic (foundry and metallurgy), mechanic (galvanic processes and painting), chemical (paints, enamels, plastic materials and Ceramic) (Ziemacki *et al.*, 1989). Road ways and automobiles now are considered to be one of the largest sources of heavy metals pollution. According to Fairfax County (2008), Zn, Cu, and Pb are three of the most common heavy metals released from road travel, which accounts for at least 90 percent of the total metals in road runoff. Pollution of the environment caused by burning of tyres which contain various hazardous chemicals such as styrene and 1, 3-butadienes is of great concern (Holder et al., 1991; Reisman, 1997; IAFC, 2000).

Once liberated into the environment through the air, drinking water, food, or countless human-made chemicals and products, heavy metals are taken into the body via inhalation, ingestion, and skin absorption. The environmental and human health effects of heavy metals depend on the mobility of each metal through environmental compartments and the pathways by which metals reach humans and the environment (Encyclopedia B, 2012).

Effect of environmental pollution on food items has been a matter of great concern for both the developing and the industrialized countries.

2.7.2 Heavy Metals in Meat and Hides

The risk of meat getting contaminated with heavy metals is a subject 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). Generally contamination of meat depends on nature and age of animal, place of animal rearing, dietary habits, slaughtering, transportation condition and exposure time (Sabir *et al.,* 2003). Toxic compounds which may be found in meat and meat products can also be traced to treatment of animals with drugs for therapeutic or nutritive purposes and pollution of the environment. Pollutants are also transferred into the animal by way of the alimentary tract, and uptake or formation of toxic compounds during processing (Cross and Overby, 1988).

In a study carried out by Obiri-Danso *et al.,* (2008), the extent of heavy metals deposited in hides from tyre fumes was dependent on the type of metal on which hides were placed and the mode of singed treatment.

Singeing of goat carcass in open fire fuelled with scrap tyres introduced less amounts of heavy metals into hide relative to the amounts introduced into cattle hides that were placed directly on metal stripes from scrap tyres. The high levels of heavy metals in both goats and cattle tyre-singed hides were as a result of both animal rearing/environmental factors and singed treatment. Continuous consumption of the hides as meat product in Ghana might have significant health implications in view of the high heavy metals content and their ability to bioaccumulate in minute concentrations.

According to the study by Obiri-Danso *et al.*,(2008) the greatest threats were presented by Pb, Cd and Zn, all of which far exceeded maximum permissible levels for meat. The hides as meat products were classified as potentially unwholesome for human consumption. Their study underscored an urgent need to regularise the activities of local butchers in Ghana to conform to best practices necessary for abattoir operations. Heavy metals in feed and food symbolize a severe risk and their long-term exposure can lead to toxicological effects. Excessive exposure of elements such as cadmium, lead, arsenic, chromium and mercury is toxic for plants, animals and human beings (Llobet *et al.*, 2003).

2.7.3 Effects of Heavy Metals on Humans

Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis (International Occupational Safety and Health Information Centre, 1999).

Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer (International Occupational Safety and Health Information Centre, 1999). Hauser *et al.*, (2009), reported that high doses of cadmium can lead to kidney failure, damage to testicles and liver. Other health effects that can be caused by high doses of cadmium are: diarrhoea, stomach pains and severe vomiting, bone fracture, reproductive failure and possibly even infertility.

Damage to the central nervous system, the immune system, possibly DNA damage and psychological disorders or cancer development, are some other effects reported. Infants and young children are more vulnerable than adults to the toxic effects of lead, and they also absorb lead more readily. Even short term, low-level exposures of young children to lead is considered to have an effect on neurobehavioral development. Lead also has an effect on brain and intellectual development in young children, while long-term exposure in both children and adults can cause damage to the kidneys, reproductive and immune systems in addition to effects on the nervous system. Similarly, increase in levels of copper causes liver, kidney and brain damage, which may follow haemolytic crisis (Shils *et al.*, 1994).

Minerals, such as magnesium, zinc, and manganese, function as co-factors in various enzyme systems of the body. Therefore, certain levels of intake are recommended. Zinc is an essential nutrient in humans and animals that is necessary for the function of a large number of metalloenzymes. As such, zinc is required for normal nucleic acid, protein, and membrane metabolism, as well as cell growth and division. Although humans can handle proportionally large concentrations of zinc, too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia.

Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and also cause arteriosclerosis. Zinc deficiency also causes anaemia and retardation of growth and development (McCluggage, 1992).Manganese effects also occur mainly in the respiratory tract and in the brains. Symptoms of manganese poisoning are hallucinations, forgetfulness and nerve damage. Manganese can also cause Parkinson's disease, lung embolism and bronchitis. Exposure to manganese in men for a long period of time can result in impotence. Exposure to high oral, parenteral, or ambient air concentrations of Mn can result in elevations in tissue levels and neurological effects (Santamaria, 2008).

Persistent over-indulgence in taking magnesium supplements can lead to muscle weakness, lethargy and confusion (Lenntech, 2012). Small amounts of Nickel are needed by the human body to produce red blood cells; however, in excessive amounts Nickel has the following consequences: higher chances of development of lung, nose, larynx and prostate cancers, lung embolism, respiratory failure, birth defects, asthma chronic bronchitis and heart disorders. Short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation (Lenntech, 2012).
Copper is an essential element for good health however, exposure to higher doses can be harmful. Long- term exposure to copper dust irritates the nose, mouth, and eyes, and causes headaches, dizziness, nausea, and diarrhea. Intentionally high intakes of copper can cause liver and kidney damage and even death (ATSDR, 2004). In order to protect human health it is essential to control levels in foodstuffs, given the wide spectrum of effects on health and the fact that these toxic metals accumulate in the body. The risk associated with the exposure to heavy metals present in food products has aroused widespread concern in human health.

Primary production should be managed in a way that reduces the likelihood of introduction of hazards and appropriately contributes to meat being safe and suitable for human consumption.

Whenever possible and practicable, systems should be established by the primary production sector and the competent authority, to collect, collate and make available information on hazards and conditions that may be present in animal populations and that may affect the safety and suitability of meat. Farming practices should be environmentally sustainable and such that there is no pollution of the land, water or air, and that existing habitats and species diversity are maintained and protected. Assuring food safety throughout every part of the food chain has thus become a vital priority for the meat industry. This has prompted a rise in national and industry-led regulations aimed at improving food safety, animal production and animal welfare (FAO, 2004).

When we ask about meat safety, we look primarily to slaughterhouses and processors. We look there for regulatory solutions. This narrow focus obscures the overall problem of meat safety, which begins with livestock-raising practices and ends with a consumer developing an illness. Furthermore, such focus throws all liability onto the consumer.

The consumer faces the risk of eating potentially contaminated meat without any information about the likelihood of contamination (Daluiso, 2012)

2.7.4 Lethal Daily Intake Values Of Some Heavy Metals

The Food and Drug Administration (FDA) of the World Health Organization (WHO), and various other governmental and private agencies in the USA and the UK have come up with recommended daily intake values of some metals as well as their toxic values.

Recommended daily intake values as well as toxic values for Cd, Pb, Mn, Zn, Mg, Ni and Cu are shown in Table 2.

Table 2: Recommended daily intake values of some metals and their toxic values

Metal	Recommended Daily Intake/mg	Toxic Intake
Cd	3-330	1.5-9g
Pb	1	10g
Mn	5	>5
Zn	15	25g
Mg	350	400mg
Ni	< 1	>1mg
Cu	2	10mg

(Source: Lenntech, (2012)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The study was conducted in the Greater Accra Metropolitan Area; samples were collected from two main slaughter sites under the supervision of the Accra Metropolitan Assembly namely the Jamestown and Avenor Slaughter Points and also from the Accra Abattoir which is run as a private entity (Fig.1). The center of population of the Greater Accra region is located in the Greater Accra Metropolitan Area which comprises the Accra Metropolitan, Tema Metropolitan, Adenta Municipal, Ashaiman Municipal, Ledzokuku-Krowor Municipal, Ga East Municipal, Ga West Municipal, and Ga South Municipal Areas.

According to the Ghana Housing and population census, year 2000, the region had a population of 2,905,726, making it the second most populous (total number of people) region of Ghana behind the Ashanti Region. Owing to in-migration and a high population growth rate, however, the region has the highest population density in the country.

Accra is the capital and largest city of Ghana, with an estimated urban population of 2,291,352 as of 2012. Accra is also the capital of the Greater Accra Region and of the Accra Metropolitan Area, with which it is coterminous. It is furthermore the anchor of a larger metropolitan area, the Greater Accra Metropolitan Area (GAMA), which is home to about 4 million people, making it the largest metropolitan conglomeration in Ghana by population. The Greater Accra area accounts for 13 percent of the total population of Ghana.

With an annual growth rate of 4.1 per cent (GSS, 2000), which is more than the national average of 3.1%, Accra is one of the fastest growing districts in Ghana. Accra stretches along the Ghanaian Atlantic coast and extends north into the country's interior. The metropolitan Area of Accra covers a land area of 894km^2 and owing to its (Greater Accra Metropolitan Area) location in the Dahomey Gap, where the coast runs parallel to the prevailing moist monsoonal winds, Accra features a tropical savanna climate that borders on a semi-arid climate. The city of Accra lies 5°33’00’’N and 0°12’00’W of Ghana. The average annual rainfall is about 730 mm, which falls primarily during Ghana's two rainy seasons. There is very little variation in temperature throughout the year. The mean monthly temperature ranges from 24.7 °C (76.5 °F) in August (the coolest) to 28 °C (82.4 °F) in March (the hottest), with an annual average of 26.8 °C (80.2 °F) (Ghanadistricts, 2012).

3.2 Study sites

Located directly South-East of the Korle Lagoon, Jamestown is one of the oldest districts in the city of Accra and has the Jamestown Fort and Jamestown Lighthouse as well known tourist sites. Since the old slaughter house was closed down in 1996, butchers have taken to singeing of animals with burning scrap tyres as fuel. Some of the Butchers relocated to the Avenor Area and set up the slaughter house there. Scrap tyres were used as the main singeing material in Avenor until 2011, when a court order forced them to put a stop to the practice; nevertheless occasionally animals were sent to the Jamestown slaughter point for singeing when large orders for meat are made. The Avenor slaughter house is located in Avenor in the industrial area just behind the Metro Mass Bus Terminal and beside the Odaw River.

The Accra Abattoir Company Limited is located on the Accra - Tema Motorway in Accra, before the Ashaiman Overhead and serves both the residents of Accra and Tema and all other butchers seeking to patronize their services. Small ruminants like goats and sheep are usually slaughtered at the Jamestown and Avenor Slaughter Points but occasionally some cattle slaughtering is done. The Accra Abattoir slaughters cattle in larger numbers than the smaller ruminants on a daily basis.

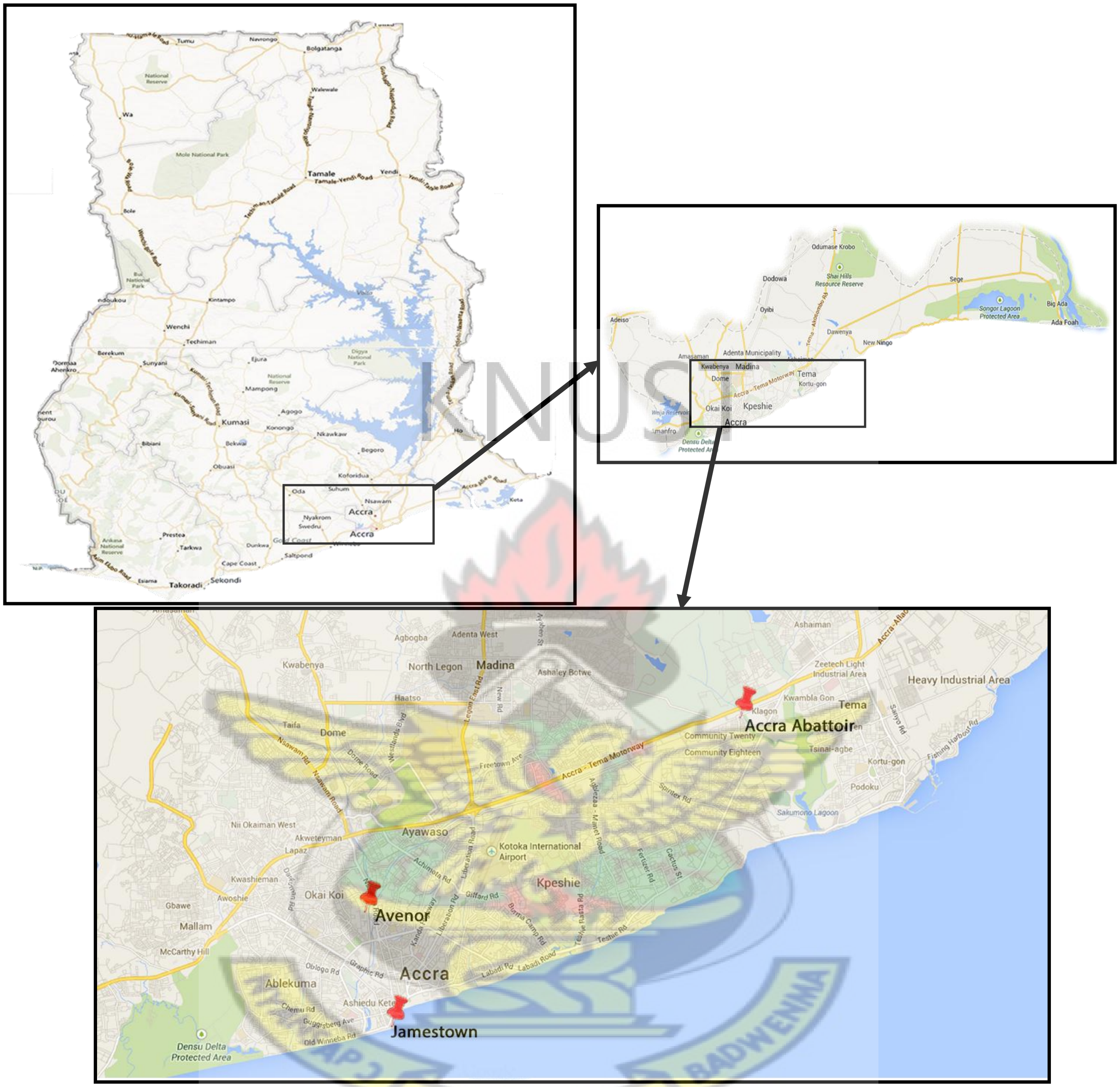

Figure 1: Map showing location of sampling points

3.3 Primary Data Collection

Primary data were collected through face- to-face interviews and questionnaires. Veterinary officers at the Jamestown slaughter point, the Avenor slaughter point and the Accra Abattoir were interviewed.

Twenty butchers at the Jamestown slaughter point were interviewed. Butchers at the Avenor Slaughter point were not interviewed because Liquefied Petroleum Gas was in use as source of fuel for singeing of slaughtered animals during data collection. Data were grouped under Personal details, Animal slaughter operation details, and work history; consumer information, scrap tyre use and practices, point of sales information and knowledge of singeing bye -laws.

3.4 Sampling:

A total of thirty six (36) samples of hides were taken from the neck region of six different goats and six different sheep from the slaughter sites. Approximately 5 g portions of hide were carefully cut from each animal near the slit on the neck where animal was slaughtered. In each case, hides were cut before singeing, after singeing and when singed carcass was washed. In all, there were six treatment groups, with six samples in each group as follows:

(i) Un-singed goat hide as controls

(ii) Singed unwashed goat hide.

(iii) Singed and washed goat hide.

(iv) Un-singed sheep hide as controls.

(v) Singed unwashed sheep hide.

(vi) Singed and washed sheep hide.

The samples were put in air tight bags (sandwich sealers), placed in an ice-chest and transported to the laboratory for chemical analysis. Summary of sample size is shown in Table 3 below.

Table 3: Sample size for hides collected

Site Number	Location Name	Number of Samples
1	Avenor	12
2	Jamestown	12
3	Accra Abattoir	12
Total		**36**

3.3.1 Water Sampling

Samples of water types used for the washing of slaughtered and singed goats and sheep were collected before washing of animal hides and analyzed to determine if the type of water used in washing of hides during processing contributed to heavy metal contamination. Water samples were collected in duplicates from the three slaughter points in this study for analysis. Sea water used at the Jamestown slaughter point and water from a well used at the Avenor slaughter point was collected and compared to tap water from the Accra Abattoir as control.

Disposable gloves were worn and water samples collected into well rinsed 500ml plastic bottles. Samples were transported to the laboratory in a cool box over ice for analysis. Water samples collected were acidified with 50% HNO_3 to attain a pH of 2 in order to keep the metal ions in the dissolved state, as well as to prevent microbial activities (APHA *et al*., 2005).

3.5 Laboratory analysis

Samples of goat hides, sheep hides and water samples were analyzed for the presence and concentration of Magnesium (Mg), Cadmium (Cd), Lead (Pb), Copper (Cu), Zinc (Zn), Nickel (Ni), and Manganese (Mn).

3.5.1 Determination of levels and concentration of metals in meat samples

One (1.0) g of meat samples oven – dried at 60 ^{o}C for twenty four hours, to constant weight were powdered in a mortar and pestle and transferred into a 125 ml Erlenmeyer flask which has been previously washed with acid and distilled water. Methods of wet digestion were adopted from Association of Official Analytical Chemists (1979), Perkin Elmer Corp. (1968), Chapman *et al*., (1961) and Piper, (1994).

Ten (10) mls of Ternary mixture of concentrated $HClO_4$: HNO_3: H_2SO_4 (20 ml: 500 ml: 50 ml) were added to the powdered sample in Erlenmeyer flask under a fume hood. Contents were mixed and heated gently at low to medium heat on a hot plate under a fume hood for 30minutes. Continuous heating was done until mixture was cleared. Strong heating was finally carried out (medium to high heat) for one minute. Mixture was allowed to cool and 40 – 50 ml distilled water added and boiled for half a minute on the same plate at medium heat. Solution was cooled and filtered completely with a Whatman No. 42 filter paper, 9 cm into a 100 ml Pyrex volumetric flask and made up to the mark with distilled water in a wash bottle.

Atomic Absorption Spectrometry was used for determining the levels of Magnesium, Copper, Cadmium, Lead, Zinc, Manganese and Nickel, in the filtrate of wet digested meat samples using Perkin Elmer 400 AAS machine at the following wavelengths:

Mn = 279.48 nm, Pb = 283.31 nm, Zn = 213.86 nm, Cu = 324.75 nm and. Cd = 228.80 nm, Ni = 232.00 nm, and Mg = 285.21 nm. The AAS machine was calibrated using standard solutions of the different metals under investigation.

3.5.2 Determination of levels and concentration of metals in water samples

For determination of levels and concentration of Magnesium, Copper, Cadmium, Lead, Zinc, Manganese and Nickel in water samples, 98 mls of each sample was measured into a 100 ml Pyrex volumetric flask already washed with distilled water. Two (2 mls) of concentrated HNO_3 was added to the sample and it was shaken and allowed to stand for about an hour. Readings were then taken using the Perkin Elmer 400, Atomic Absorption Spectrometer machine at the following wavelengths: Mn = 279.48 nm, Pb = 283.31 nm, Zn = 213.86 nm, Cu = 324.75 nm and. Cd = 228.80 nm, Ni = 232.00 nm and Mg = 285.21 nm.

3.6 Geographical Positioning System (GPS) coordinates for sampling points

GPS Handheld device (Garmin Etrex H) was used to take all geographical locations of the slaughter points and all Primary distribution points of meat from the Jamestown slaughter point. The locations were given in coordinates, latitude and longitude.

3.7 Statistical Analysis

Concentrations of heavy metals were expressed as mean ± SEM (standard error of mean). One way ANOVA was used to compare means among treatments and differences resulting in $p<0.05$ were considered significant. EXCEL 2007 statistical software and SPSS 16.0 all for MICROSOFT were used for ANOVA computations and analysis of questionnaire data.

CHAPTER FOUR

4.0 RESULTS

Analysis of fresh unsinged goat and sheep hides at all three slaughter points revealed sub-lethal levels of all the metals under investigation, except Zn which exceeded the maximum permissible value of 50 mg/kg (USDA, 2006; OJEC, 2001). In goat and sheep hides singed with vehicle scrap tyres and LPG, Pb and Cadmium was not detected in any of the samples before singeing however after singeing and washing, traces of Cadmium were detected in some samples singed with scrap vehicle tyres but no Pb was detected.

The results of heavy metal concentrations in unsinged, singed and unwashed and singed and washed hides of slaughtered goats and sheep from the Accra Abattoir, Avenor slaughter point and Jamestown slaughter point analyzed are presented in Figures 2 to 7.

4.1 Metal concentrations in the hides of goats slaughtered at Avenor

The Avenor slaughter house employed the use of Liquefied Petroleum Gas (LPG) as source of fuel with a hand held burner in the singeing of slaughtered goats on the floor. Metal concentrations in the hides of unsinged, singed unwashed and singed washed goats are given in Figure. 2.

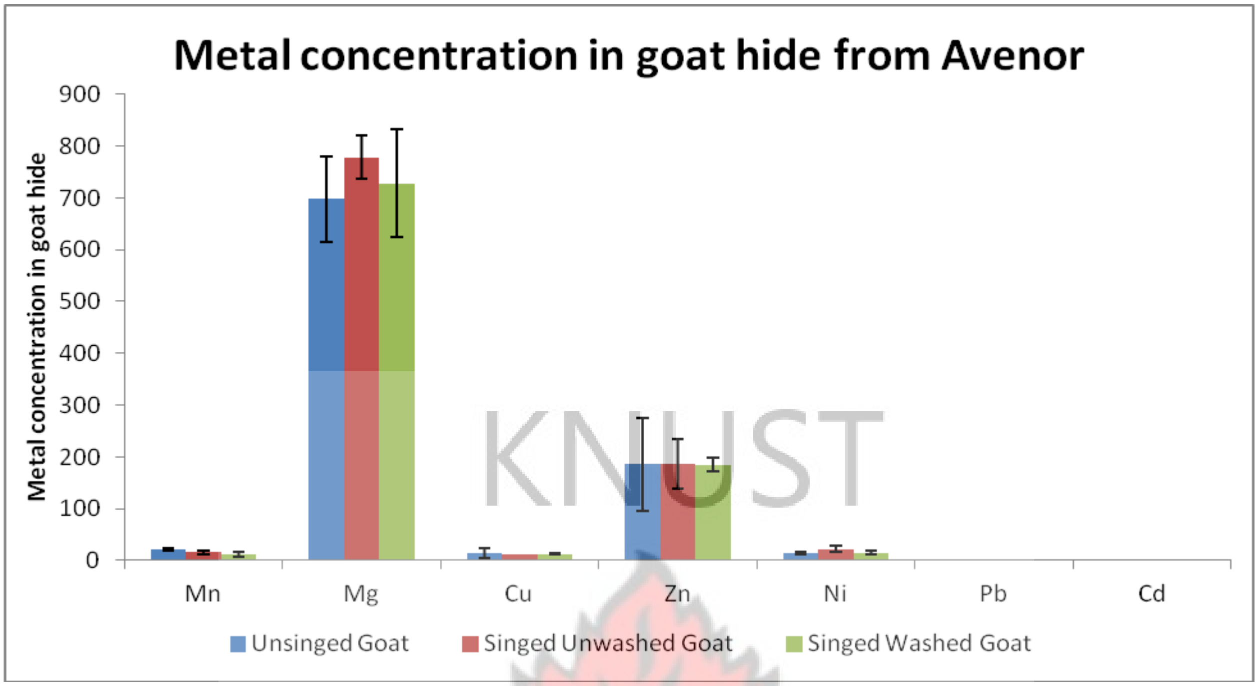

Figure 2: Metal concentrations in unsinged, singed unwashed and singed and washed goats' hides (singed with LPG as fuel) at Avenor.

The concentrations of Mn, Mg, Cu, Zn and Ni in fresh unsinged goat hides were 20.7±2.6 mg/kg, 697.5±82.1 mg/kg, 13.65±9.65 mg/kg, 185.55±90.15 mg/kg, and 14.75±1.95 mg/kg respectively. Whilst lower concentrations of Mn and Cu in goat hides, 16.05±3.25 mg/kg and 11.45±0.65 mg/kg respectively were recorded after singeing, higher levels of Mg, Zn and Ni, 778±41.5 mg/kg, 186±47.6 mg/kg, and 22.2±5.7 mg/kg respectively were however recorded in goat hides after singeing. For the singed and washed goat hides, still lower concentrations of Mn, 12.2±5 mg/kg was recorded in washed samples when analyzed.

Lower concentrations of Mg, Zn and Ni, 728.2±103.1 mg/kg, 184.55±12.85 mg/kg, and 15.2±3.9 mg/kg respectively were recorded after washing compared to singed and unwashed hides.

For Cu however, higher levels of 12.95±1.45 mg/kg were recorded after washing of the singed hides.

Pb and Cd concentrations were not detected in unsinged, singed and unwashed and singed and washed hides. Variation in metal concentrations in the hides of control (unsinged goat) compared with the singed unwashed goat and singed and washed goat were statistically insignificant (P>0.05).

4.2 Metal concentrations in the hides of sheep slaughtered at Avenor

The Avenor slaughter house employed the use of Liquefied Petroleum Gas (LPG) fuel with a hand held burner in the singeing of slaughtered sheep on the floor just like the goats. Metal concentrations in the hides of unsinged, singed unwashed and singed and washed sheep are given in Figure. 3.

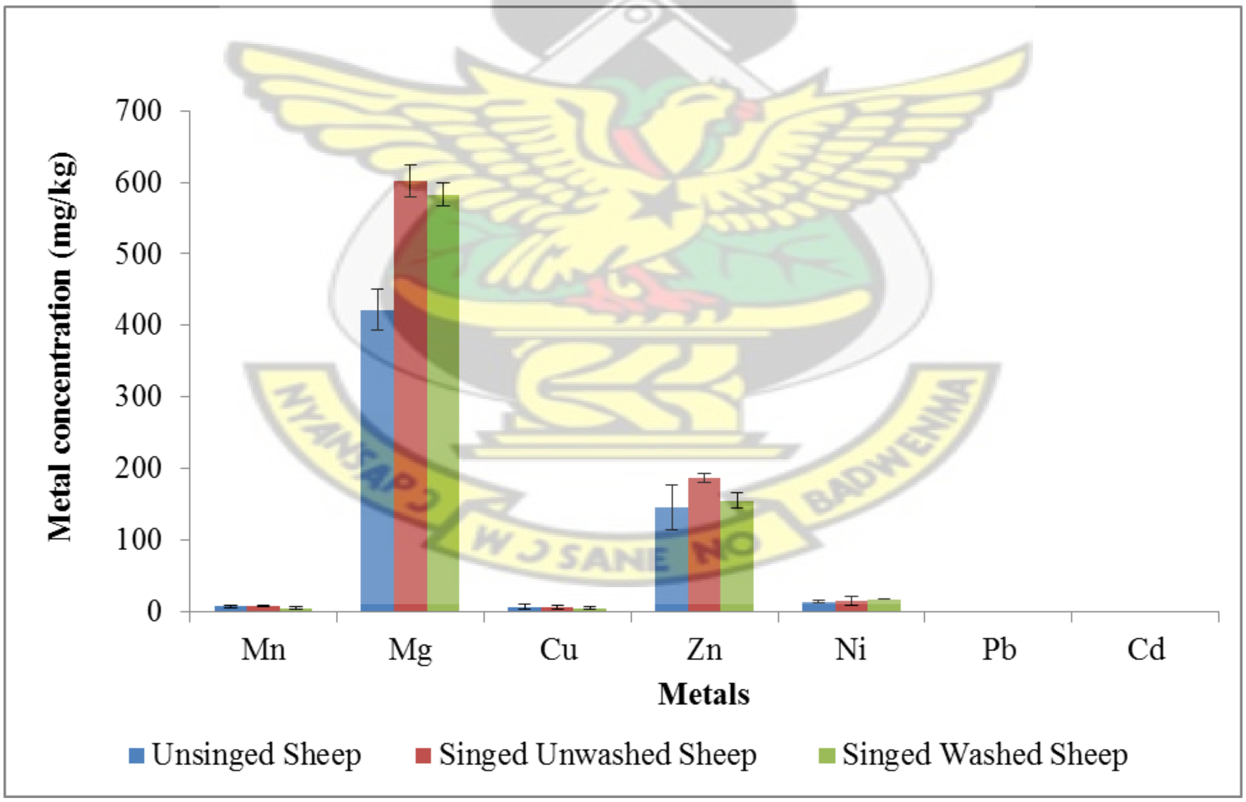

Figure 3: Metal concentrations in unsinged, singed unwashed and singed washed sheep hides (singed with LPG as fuel) at Avenor.

The concentrations of Mn, Mg, Cu, Zn and Ni in fresh unsinged sheep hides at the Avenor site were 8.1±1.9 mg/kg, 422.05±28.05 mg/kg, 7.3±3.1 mg/kg, 146±30.5 mg/kg and 14.2±1.4 mg/kg respectively, which were considerably much lower than those in fresh unsinged goat hides. Pb and Cd were however not detected. After singeing, Mn, Mg, Zn and Ni concentrations in singed unwashed hides 8.45±0.25 mg/kg, 601.95±22.45 mg/kg, 187.25±6.95 mg/kg and 16.1±6.6 mg/kg respectively were higher compared to levels in the fresh unsinged sheep hides. For Cu however, lower levels 6.4±2.4 mg/kg was recorded in the singed unwashed sheep hides.

Pb and Cd were not detected after singeing. Variations in metal concentrations between the hide of unsinged sheep (control) and the hide of singed unwashed sheep was statistically insignificant ($P>0.05$) except for Mg ($P<0.05$). After washing singed sheep hides, lower concentrations of Mn, Mg, Cu and Zn, 5.6±1.4 mg/kg, 582.96±15.74 mg/kg, 5.65±1.85 mg/kg, and 155.75±10.15 mg/kg respectively were recorded compared to values in singed unwashed hides. Higher Ni concentrations of 17.8±0.2mg/kg were however recorded. Pb and Cd were not detected in any of the samples. The variation in metal concentrations between unsinged (control) and singed and washed sheep hides were statistically insignificant ($P>0.05$) except for Mg ($P<0.05$) that recorded a significant increase.

In summary, even though Cu levels in goat hides increased after washing and Ni levels decreased, the opposite was observed in sheep hides analyzed at the Avenor slaughter point. Cu levels recorded in both sheep and goat hides were below the maximum permissible level (MPL) of 20 mg/kg. The Zinc levels in all the samples of goat and sheep and even fresh unsinged hides were higher than the maximum permissible value of 50 mg/kg (USDA, 2006; OJEC, 2001). MPL's have not been established for Mg, Mn and Ni in meat.

4.3 Metal concentrations in goat hides singed with burning vehicle tyres as fuel at Jamestown

The Jamestown slaughter point used vehicle scrap tyres as fuel in the singeing of slaughtered goats. Slaughtered goats were placed on a pile of burning scrap tyres with very little wood and slaughtered animals were slowly turned on the fire to completely singe the fur off the animal. Metal concentrations in unsinged, singed unwashed and singed and washed goat hides are given in Figure. 4.

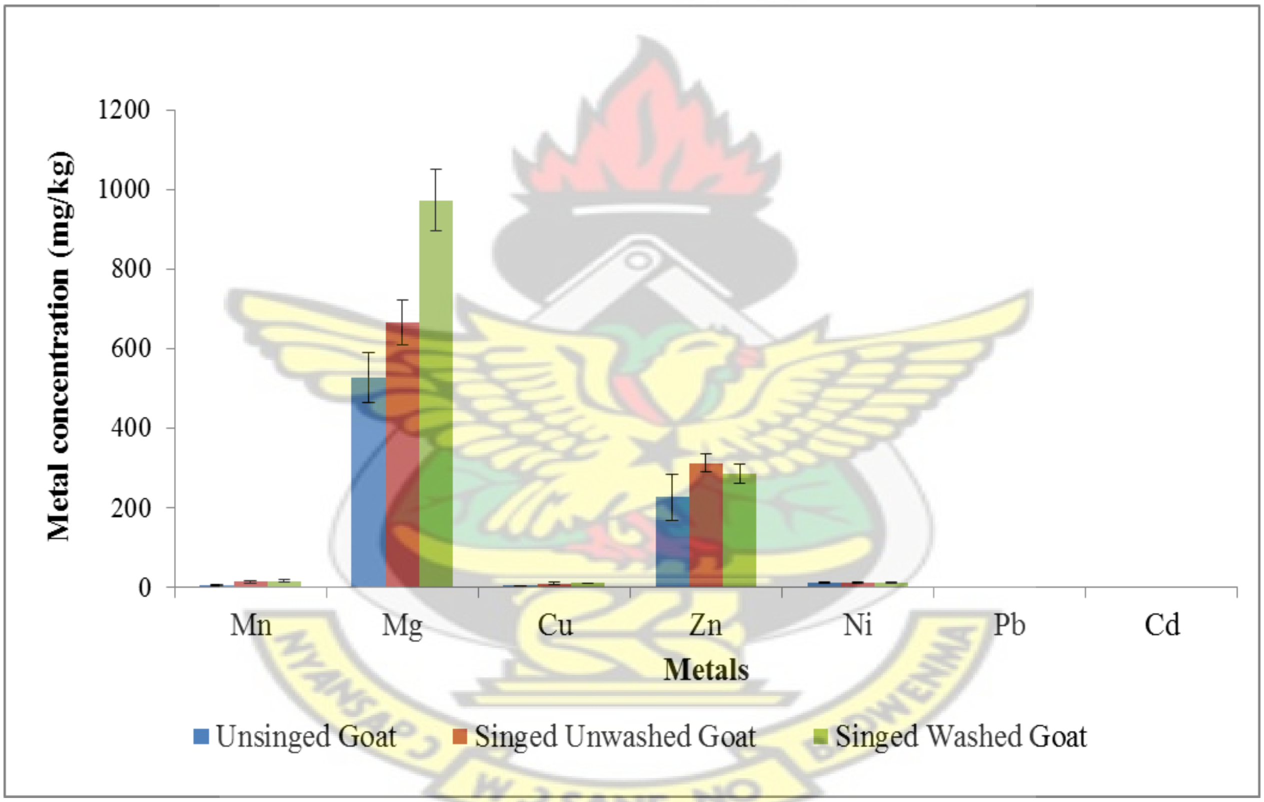

Figure 4: Metal concentrations in unsinged, singed unwashed and singed and washed goat hides (singed with burning tyres as fuel) at James town.

The concentrations of Mn, Mg, Cu, Zn and Ni in fresh unsinged goat hides obtained from the Jamestown slaughter point were 6.45±0.55 mg/kg, 528.35±62.95 mg/kg, 5.3±0.8 mg/kg, 226.9±56.9 mg/kg and 12±1.8 mg/kg respectively. Pb and Cd concentrations were not detected in fresh unsinged goat hides. When these samples were singed using vehicle scrap tyres as fuel, higher concentrations of Mn, Mg, Cu, Zn and Ni, 14.75±2.45 mg/kg, 667.35±56.35 mg/kg, 10.9±2.7 mg/kg, 312.5±22.5 mg/kg, and 13.7±1.5 mg/kg, respectively was recorded. Pb and Cd were not detected after singeing. After singeing Pb was still not detected, however, trace concentration, 0.005±0.001 mg/kg of Cd was recorded.

The variations in metal concentrations between the control (unsinged) and singed unwashed goat hides were statistically insignificant (P>0.05). After washing of the singed goat hides however, increases in concentrations of Mn, Mg, and Cu, 17.4±1.9 mg/kg, 973.25±75.75 mg/kg and 11.45±0.25 mg/kg respectively were recorded even though it was expected that washing of singed hides would lead to decreases in metal levels. The variations in Mn, Mg and Cu concentration between the singed and washed hides and the control (unsinged) hides were statistically significant (P<0.05). Lower Zn and Ni concentrations of 287.5±24.5 mg/kg, and 12.7±1.3 mg/kg respectively however, were recorded when the singed hides were washed. The variation in Zn and Ni concentrations were statistically insignificant (P>0.05) compared to the control (unsinged hides). Cd and Pb were not detected in any of the hides after washing.

4.4 Metal concentrations in sheep hides singed with burning vehicle scrap tyres at Jamestown

As with goats, the Jamestown slaughter point used scrap tyres as fuel in the singeing of slaughtered sheep. Metal concentrations in unsinged, singed unwashed and singed and washed goat hides are given in Figure 5.

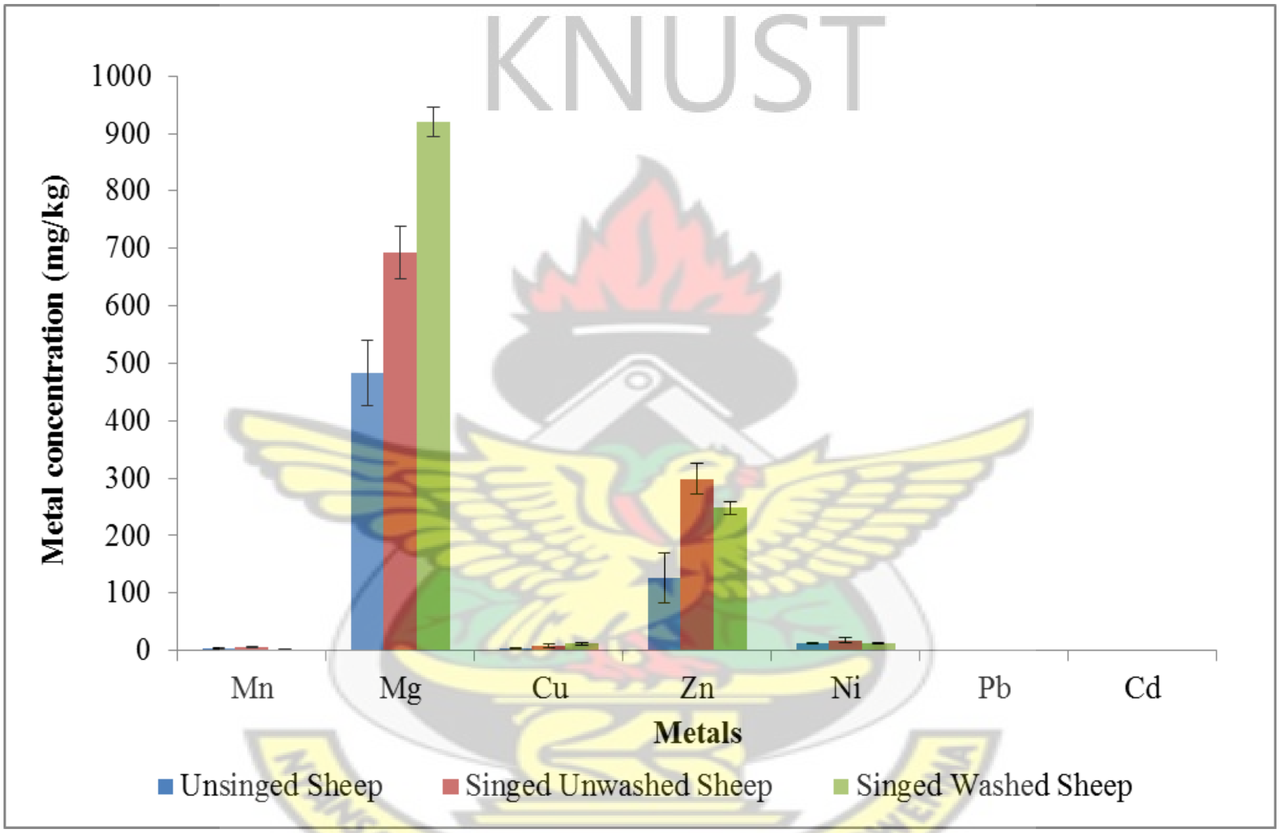

Figure 5: Metal concentrations in unsinged, singed unwashed and singed and washed sheep hides (singed with burning tyres as fuel) at Jamestown

In fresh unsinged sheep samples obtained from Jamestown, the concentrations of Mn, Mg, Cu, Zn and Ni in the hides were 3.55±1.05 mg/kg, 482.85±57.35 mg/kg, 3.55±0.95 mg/kg, and 126.8±43 mg/kg and 11.8±0.9 mg/kg respectively.

These were generally lower than the levels found in the goat samples. Higher Mn, Mg, Cu, Zn, Ni concentrations, for sheep hides, 5.6±1.9 mg/kg, 693.05±45.85 mg/kg, 8.6±3.1 mg/kg, 298.25±26.75 mg/kg and 17.75±4.75 mg/kg respectively were recorded after singeing with vehicle scrap tyres than in fresh unsinged sheep hides. Pb and Cd were not detected in any of the unsinged hides neither was Pb detected after singeing but a trace concentration of Cd 0.0015±0.0015 mg/kg was detected.

After singed sheep hides were washed, lower Mn concentrations of 1.0±1.0 mg/kg, higher concentrations of Mg and Cu, 920.3±25.3 mg/kg and 11.75±1.95 mg/kg respectively and lower concentrations of Zn and Ni respectively 247.9±12.1 mg/kg and 13.05±1.45 mg/kg were recorded. Apart from Mn that recorded lower levels in singed and washed sheep, whilst an increase was recorded in singed and washed goats, all the other metals in both singed and washed goats had a similar trend in increases and decreases at the Jamestown slaughter point.

Pb and Cd were not detected in washed sheep hides. Variations in metal concentrations between the control (unsinged hides) and the individual samples of singed unwashed and singed and washed hides were statistically insignificant ($P>0.05$) for all metals except for the concentration of Mg in singed and washed hides that was statistically significant compared to controls (unsinged) ($P<0.05$). Cu was below the maximum permissible limit of 20 mg/kg in fresh unsinged, singed unwashed and singed and washed goat and sheep hides from the Jamestown slaughter site. The Zinc levels in all the samples of goat and sheep and even fresh unsinged hides were higher than the maximum permissible value of 50 mg/kg (USDA, 2006; OJEC, 2001). MPL's have not been established for Mg, Mn and Ni in meat.

4.5 Metal concentrations in goat hides singed with LPG as Fuel Source at Accra Abattoir

Singeing of slaughtered animals at the Accra Abattoir was carried out in a singeing chamber fueled by LPG connected to rod burners by a system of hoses. Slaughtered animals were hanged and singed. Metal concentrations in unsinged, singed unwashed and singed and washed goat hides at the Accra abattoir are given in Figure 6.

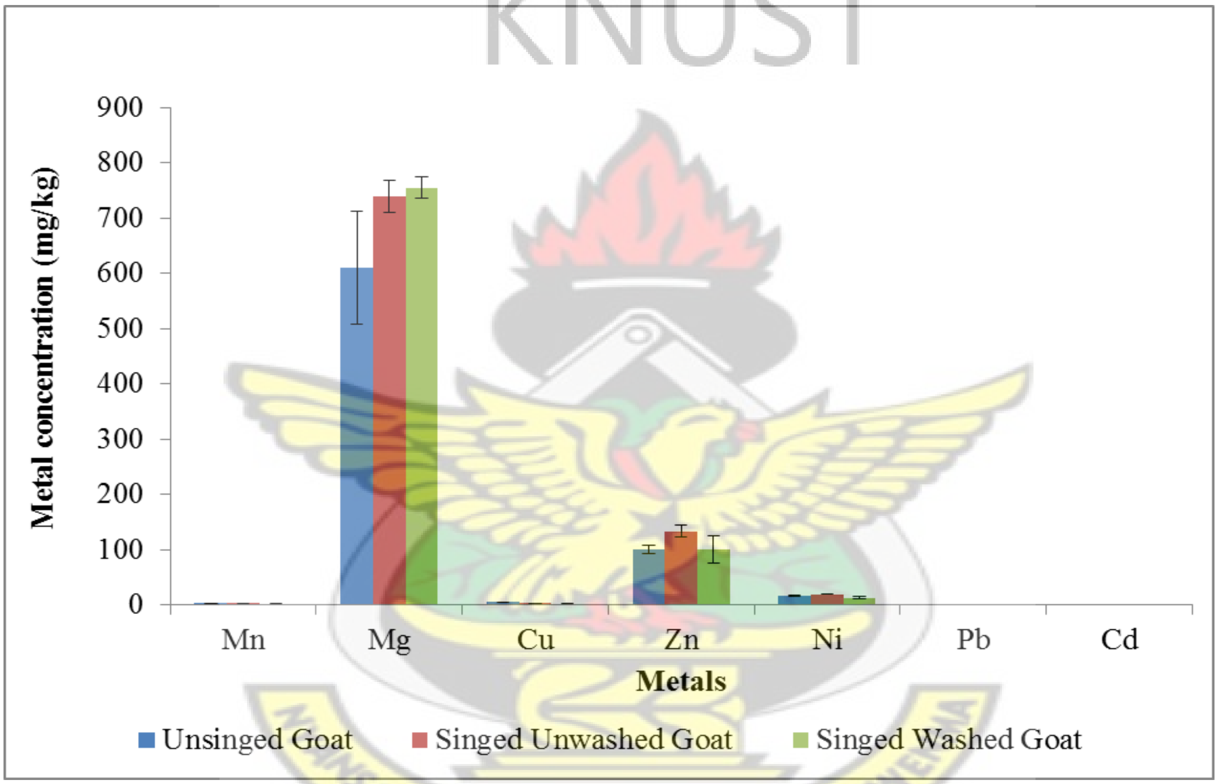

Figure 6: Metal concentration in goat hides of unsinged, singed unwashed and singed and washed (singed with LPG as fuel) at Accra Abattoir.

The concentrations of Mn, Mg, Cu, Zn and Ni in fresh unsinged goat hides at the Accra Abattoir were 3.15±0.65 mg/kg, 611.4±102.2 mg/kg, 4.95±0.75 mg/kg, 101.2±7.3 mg/kg and 16.7±0.4 mg/kg respectively**.** Higher concentrations of Mn, Mg, Zn and Ni, 3.5 ±1.0 mg/kg, 739.35±28.85 mg/kg, 133.85±10.35 mg/kg and 19.75±0.75 mg/kg respectively were recorded after singeing.

The concentrations of Cu were however lower, 3.45±0.05 mg/kg compared to concentrations in unsinged goat hides. After washing of singed goat hides, lower concentrations of Mn, Cu, and Zn were recorded, 2.15±0.95 mg/kg, 2.7±0.3 mg/kg, and 101.4±24.6 mg/kg respectively as compared to the singed unwashed goat hides.

However, higher Mg concentrations of 755.75±18.25 mg/kg and lower Ni concentrations of 13.35±1.75 mg/kg were also recorded when singed unwashed goat hides were washed. Pb and Cd were not detected in all three categories of samples (unsinged, singed unwashed and singed and washed). Statistically, variations in metal concentrations between the control (unsinged hide) and singed unwashed and singed and washed hides were insignificant ($P>0.05$).

4.6 Metal concentrations in sheep hides singed with LPG as source of fuel at Accra Abattoir

Slaughtered sheep are singed in the Accra Abattoir just like the slaughtered goats. Metal concentrations in unsinged, singed unwashed and singed and washed sheep hides at the Accra abattoir are given in Figure 7.

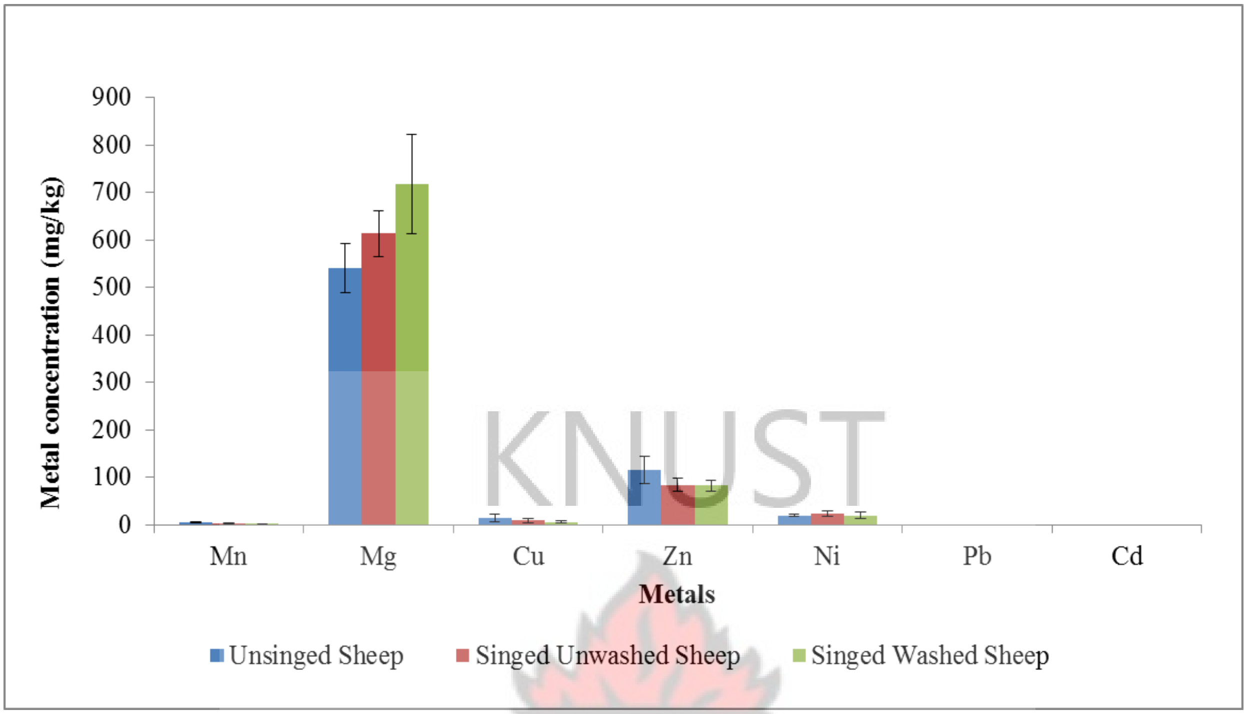

Figure 7: Metal concentration in sheep hides of unsinged, singed unwashed and singed and washed (singed with LPG as fuel) at Accra Abattoir.

The concentration of Mn, Mg, Cu, Zn and Ni in fresh unsinged sheep hides were 4.75±0.95 mg/kg, 540.2±51.2 mg/kg, 13.5±8.5 mg/kg, 115.33±29.05 mg/kg and 19.61±2.61 mg/kg respectively. After singeing, whilst lower concentrations of Mn, Cu, and Zn 2.4±1.2 mg/kg, 8.8±4.1 mg/kg, and 83.435±13.67 mg/kg respectively were recorded, higher Mg and Ni concentrations of 613.3±47.4 mg/kg and 23.1±5.0 mg/kg respectively, were also recorded as compared to the fresh unsinged hides. Unlike singed goat hides that recorded only lower Cu levels after singeing, sheep hides recorded lower levels in Mn and Zn as well compared to levels in the unsinged hides.

Washing of singed sheep samples obtained from the Accra Abattoir, recorded still lower concentrations of Mn, Cu, Zn and Ni, 0.25±0.25 mg/kg, 5.48±1.68 mg/kg, 82.07±11.83 mg/kg and 19.435±6.135 mg/kg respectively as compared to concentrations in singed unwashed sheep hides except Mg that increased to 717.665±104.335 mg/kg. Variations in metals concentration between unsinged and singed sheep hides, were statistically insignificant ($P>0.05$). The same applies to unsinged hides and singed and washed sheep hides ($P>0.05$) except for Mn that recorded a significant decrease ($P<0.05$). Pb and Cd were not detected in any of the samples. Cu was below the maximum permissible limit of 20 mg/kg in fresh unsinged, singed unwashed and singed and washed goat and sheep hides at the Accra Abattoir. Zn levels were 101.2±7.3 mg/kg in fresh unsinged goats and were higher than in singed washed samples that recorded 101.4±24.6 mg/kg. Zn levels in fresh unsinged sheep 115.33±29.05 mg/kg also became lower 82.07±11.83 mg/kg when sheep hides were singed and washed.

The Zinc levels in all the samples of goat and sheep and even fresh unsinged hides were higher than the maximum permissible value of 50 mg/kg (USDA, 2006; OJEC, 2001). MPL's have not been established for Mg, Mn and Ni in meat.

4.7 Results for metal concentrations in sampled water for the washing of Singed Hides at the Avenor slaughter point, Jamestown slaughter point and the Accra Abattoir

Water for the washing of singed slaughtered sheep and goats was obtained from each slaughter point in the study as they all used water from a different source. Water from the Avenor slaughter point (Well water), Jamestown slaughter point (Sea water) and the Accra Abattoir (Tap water) were analyzed for concentrations of Manganese, Magnesium, Copper, Zinc, Nickel, Lead and Cadmium. Mean concentrations in present study are given in Table 4 below.

Table 4: Metal concentrations in sampled water for washing of singed hides at the Jamestown slaughter point, Avenor Slaughter and the Accra Abattoir.

WATER SAMPLES FOR THE WASHING OF SINGED HIDES				
Metal Concentrations (ppm)		**JAMESTOWN (Sea Water)**	**AVENOR (Well Water)**	**ACCRA ABATTOIR (Tap Water)**
Mn	Mean	0.0033	0.279	ND
	SEM	±0.001	±0.018	
Mg	Mean	675.367	61.13	14.75
	SEM	±32.26	±3.43	±0.66
Cu	Mean	ND	ND	ND
	SEM			
Zn	Mean	0.015	0.039	0.154
	SEM	±0.004	±0.036	±0.006
Ni	Mean	0.208	0.066	ND
	SEM	±0.006	±0.009	
Pb	Mean	0.0543	ND	ND
	SEM	±0.007		
Cd	Mean	0.13	0.035	0.034
	SEM	±0.017	±0.006	±0.007

Water from the Avenor and Jamestown slaughter points, recorded mean Mn concentrations of 0.0033±0.001 ppm and 0.279±0.018 ppm respectively; however no Mn concentrations were recorded in water obtained from the Accra Abattoir.

Water from the Jamestown slaughter point recorded the highest mean concentrations in Mg, 675.367±32.26 ppm, the Avenor slaughter recorded 61.13±3.43 ppm and the lowest values of 14.75±0.66 ppm were recorded in water samples from the Accra Abattoir. No Cu concentrations were recorded in any of the water samples obtained from all study sites. At the Jamestown and Avenor slaughter points mean Zinc concentrations recorded were 0.015±0.004 ppm and 0.039±0.036 ppm respectively whilst water samples from the Accra Abattoir recorded mean Zn concentrations of 0.154 ±0.006 ppm.

Variations in Zn concentrations in water obtained from Jamestown compared to the control (tap water) from the Accra Abattoir were statistically insignificant ($p>0.05$) however values from Avenor were statistically significant ($p<0.05$) when compared to controls from the Accra Abattoir. Concentrations of Ni in samples from the Jamestown and Avenor slaughter points were 0.208±0.006 ppm, 0.066±0.009 ppm respectively, Ni concentrations were however not detected in water samples from the Accra Abattoir. Apart from the Jamestown slaughter point that recorded 0.0543±0.007 ppm in Pb concentrations, no other Pb concentrations were recorded from other study sites. The concentrations of Cd recorded in water samples from the Jamestown and Avenor slaughter points and the Accra Abattoir were 0.13±0.017 ppm, 0.035±0.006 ppm and 0.034 ±0.006 ppm respectively.

Jamestown slaughter point recorded the lowest concentrations of Cd but variations were statistically significant ($p<0.05$) compared to Cd levels in samples from the Accra Abattoir whilst Cd concentrations in samples from Avenor turned out to be insignificant ($p>0.05$).

4.8 Results of interview with respondents (butchers)

Questionnaires administered to a total of 20 respondents constituting butchers and people who work at the Jamestown slaughter point sought to determine motives for using scrap tyres in singeing of animals and where the meat was distributed to and sold. Data collected from the exercise were analyzed using the Statistical Product Solutions (SPSS) and results presented below.

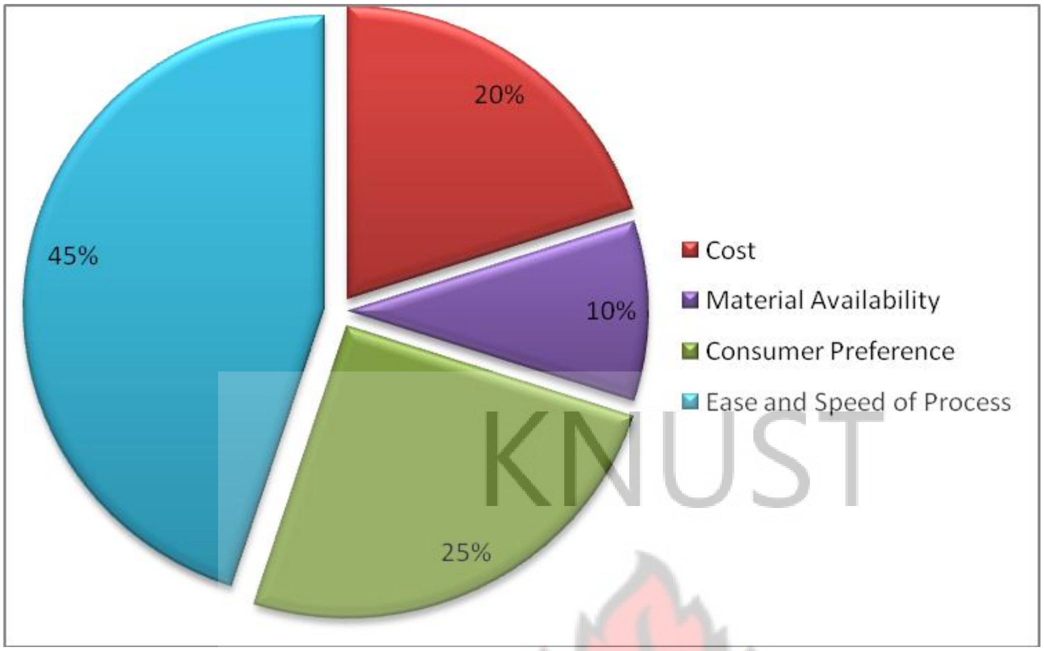

Figure 8: Butcher's reasons for using scrap tyres in the singeing of animals

Figure 8 shows that 20% of butchers interviewed stated that the high cost of LPG and the other accessories (e.g. cylinders, regulators and burners) made them resort to the use of vehicle scrap tyres that were much cheaper. Secondly, 10% of them also said that frequent gas shortages that plagued the metropolis caused them to resort to the use of vehicle scrap tyres that were always readily available. Twenty five percent (25) % of the butchers attributed Consumer preference for singed hides as their motivation for using vehicle scrap tyres in processing slaughtered animals. On the other hand 45% of the butchers also said it was much easier and faster to singe slaughtered animals over a flame fueled by scrap tyres slit into smaller pieces to make them easily combustible and, several animals can be singed within a relatively shorter time than using LPG fueled Burners.

With regards to butchers' knowledge of existing laws governing the use of vehicle scrap tyres for singeing in Ghana, 65% confirmed they had knowledge of such laws. Butchers were also asked possible factors that could influence them to adopt safe singeing methods in their operations. Responses received are shown in Figure 9.

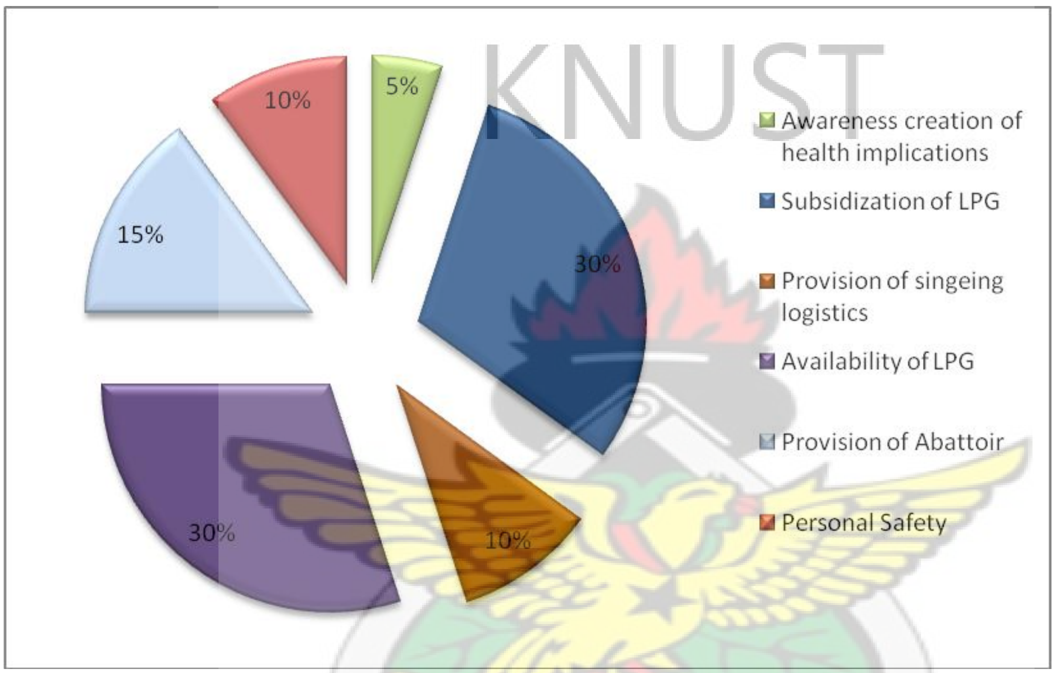

Figure 9: Factors that butchers admitted would influence their adoption of a safe singeing method

From the responses, 5% reported that they would adopt safer method if they(Butchers) would be enlightened through Awareness creation and sensitization on the dangers involved in processing meat with vehicle scrap tyre; 30% of them also spoke about government subsidizing the Liquefied Petroleum Gas used for singeing just like subsidies were given fishermen and farmers in their line of food production; 10% said that they would adopt a safer method of meat processing if singeing logistics such as Gas Burners , Regulators and Cylinders were provided.

Thirty percent (30%) said if LPG were readily available every time they needed it they would not have to use vehicle scrap tyres for singeing whilst 15% said the problem of using vehicle scrap tyre in meat processing would be solved if a regulated Abattoir was built at the Jamestown Slaughter site as the Accra Abattoir was too far away.

4.9 Point of Sales Information

In a quest to find which consumers were being supplied unknowingly with meat which had been processed using vehicle scrap tyres as fuel for singeing and sea water for washing the singed hides, the butchers at the Jamestown slaughter point were asked where they sold their processed meat. It was found that meat which had been compromised in this way was sold in most major markets in the Accra Metropolis. The GPS coordinates of all primary points of sale are plotted in red on the map below (Figure 10).

Figure 10: Map showing sales points of meat from Jamestown slaughter point

CHAPTER FIVE

5.0 DISCUSSION

Analysis of the hides of goats and sheep that had been singed using Liquefied Petroleum Gas and Vehicle scrap tyre as fuel at the three slaughter points, (viz, Avenor slaughter point, Jamestown slaughter point and the Accra Abattoir) revealed that Pb and Cd were not present in any of the fresh unsinged, singed unwashed and singed and washed goat and sheep hides at all the study sites except for traces of Cd found in singed unwashed goat and sheep hides from the Jamestown slaughter point, 0.005±0.001 mg/kg and 0.0015±0.0015 mg/kg respectively. However no traces were detected after the washing of these hides.

In comparing the concentrations of heavy metals in hides singed at the different slaughter points, it was realized that at the Avenor site, fresh (unsinged) goat hides singed with LPG as fuel, were higher in Mg, Zn and Ni concentrations by 11.54%, 0.21%, and 50.51% respectively and lower in concentrations by 23.16% in Mn and 16.12% in Cu than in fresh unsinged goat hides.
Fresh unsinged sheep hides also were higher in concentrations by 42.63% in Mg, 28.25% in Zn, and 13.38% in Ni after singeing of sheep hides. Although concentrations of Cu were lowered by 12.33%, Mn concentration was higher by 4.32% unlike the lower levels recorded after singeing of goat hides with LPG as fuel. These changes in concentrations were however statistically insignificant ($P>0.05$). As part of the procedure in the processing of slaughtered animals, animal hides have to be washed after singeing to remove char deposited on the hides from singeing the fur before sending meat products to be sold on the market. It was expected that washing the char off singed samples would lead to a reduction in levels of metals deposited by the process.

Even though reductions were recorded as expected, some increases were also recorded even though not anticipated. The Avenor slaughter site recorded lower concentrations of Mn, Mg, Zn and Ni after washing of singed goat hides, than in the singed unwashed hides even though these changes were statistically insignificant ($P>0.05$) compared to fresh unsinged goat hides. However, statistically insignificant increases ($P>0.05$) were observed in Cu concentrations from 11.45±0.65 mg/kg to 12.95±1.45 mg/kg when singed unwashed goat hides were washed. Singed and washed sheep hides recorded lower concentrations in Mn, Mg, Cu, and Zn, compared to the singed unwashed samples. Higher concentrations of Ni were recorded when singed unwashed samples were washed from 16.1±6.6 mg/kg to 17.8±0.2 mg/kg in sheep hides; variations were however statistically insignificant compared to concentrations in fresh unsinged hides.

The Jamestown slaughter point alone recorded higher levels in Cu and in all metals in this study with the exception of Pb when fresh unsinged goat and sheep hides were singed using vehicle scrap tyres as fuel. Fresh unsinged goat hides after singeing were higher in concentrations by 128% in Mn, 26.3% in Mg, 105.66% in Cu, 37.73% in Zn and 14.17% in Ni levels compared to their fresh unsinged state. Concentrations also increased by 57% in Mn, 43.53% in Mg, 142.25% in Cu, 135.21% in Zn and 50.42% in Ni when fresh unsinged sheep hides were singed. Washing of the scrap tyre singed goat hides resulted in insignificantly lower concentrations in Zn and Ni and significantly higher concentrations in Mn, Mg and Cu from 14.75±2.45 mg/kg to 17.4±1.9 mg/kg, 667.35±56.35 mg/kg to 973.25±75.75 mg/kg and 10.9±2.7 mg/kg to 11.45±0.25 mg/kg respectively when washed ($P<0.05$) to the controls.

Washing of scrap tyre singed sheep hides resulted in insignificant lower concentrations ($P>0.05$), in Mn, Zn and Ni compared to the fresh unsinged sheep hides.

Concentrations of Mg and Cu were significantly higher compared with the controls after washing as Mg and Cu concentrations increased from 693.05±45.85 mg/kg to 920.3±25.3 mg/kg and from 8.6±3.1 mg/kg to 11.75±1.95 mg/kg, respectively, when washed. Concentrations of metals in goat hides obtained from the Accra Abattoir were increased by 11% in Mn, 20.95% in Mg, 32.06% in Zn and 18.26% in Ni; however concentrations of Cu decreased by 30.30% after singeing with LPG as fuel compared to their fresh unsinged state. After singed goat hides were washed at the Accra Abattoir, lower concentrations were recorded for all metals compared to concentrations in their singed state though statistically insignificant (P>0.05). The concentration of Mg however increased insignificantly compared to levels in singed hides (P>0.05). Mg concentrations in goat hides singed and washed increased from 739.35±28.85 mg/kg in the unwashed hides to755.75±18.25 mg/kg.

Singed sheep hides recorded reduced metal concentrations by 49.47% in Mn, 34.81% in Cu, and 27.66% in Zn except in the case of Mg and Ni where concentrations increased by 13.53% and 17.8% respectively compared to the controls. After washing of singed sheep hides Mn, Cu, Zn, and Nickel recorded insignificantly lower concentrations (P>0.05), Mg only was insignificantly higher (P>0.05,) compared to the controls as it increased from 613.3±47.4 mg/kg to 717.67±104.34 mg/kg. Washing of the singed hides brings about the scraping of some char of the surface of the hide. Okiei *et al*., (2009) reported that the scrapings (ash) from the burnt (singed) hides contain substantial amounts of these metals and may be the cause of the reduced levels in singed products and this could have resulted in the decrease of the concentrations of some metals when singed goat and sheep hides were washed as observed in the present study.

However, Obiri-Danso *et al*., (2008) also reported that it appeared the water used in washing the hides introduced additional sources of Mg, Mn and Cu into the hides as washing the char off the singed hides with water, caused Mg, Mn and Cu concentrations in the hide of goat carcass to increase. This trend was also observed in the present study as levels of Mn, Mg and Cu in scrap tyre singed goat hides increased when washed and Mg and Cu also increased in the washed scrap tyre- singed sheep hides at the Jamestown slaughter point. Mg levels also increased in singed and washed goat and sheep hides at the Accra Abattoir. Ni and Cu also increased in sheep and goat hides respectively at the Avenor slaughter point.

Water sampling was carried out a few weeks after results from analysis of hides were obtained at all the slaughter points to have an understanding of the overall input of metals that could be in the water used during processing of hides. Results obtained from water analysis do not reflect levels in animal hides analyzed, even though it explains increases recorded. This probably explains why increases in metal concentrations were not detected in some hides even though it was present in the sampled water. Analysis of heavy metals in sea water used for washing of singed goat and sheep hides at the Jamestown slaughter point confirmed the presence of Mn, Mg, Zn, Ni, Pb and Cd in sea water obtained from the Jamestown slaughter point. At the Avenor slaughter point however, concentrations of Mn, Mg, Zn, Ni and Cd were detected whilst, Mg, Zn ad Cd only were detected in water from the Accra Abattoir. Magnesium is responsible for water hardness; according to NAS, (1989) hard water contains more Mg than soft water. Magnesium levels in water samples analyzed from the Jamestown slaughter point were considerably higher 675.37 ±32.26 ppm than those recorded for Avenor and Accra Abattoir, 61.13±3.43 ppm and, 14.75±0.66 ppm respectively.

The vast difference in increases in Mg levels when hides were washed with seawater at the Jamestown slaughter point compared with those for the others could also be attributed to the high Mg content in the hides at Jamestown. Concentrations of Copper, were however, not detected in any of the water samples, namely sea water, well water or tap water analyzed from the study sites even though Cu increases were recorded when goat and sheep hides at the Jamestown slaughter point were washed and also in washed goat hides at the Avenor slaughter point.

Water sampled from the Avenor slaughter point recorded higher levels of Manganese, 0.279±0.018 ppm than water from Jamestown 0.0033±0.001 ppm whilst no Mn concentrations were recorded in water from the Accra Abattoir. However, no increases were observed in Mn, when goat and sheep hides from the Avenor slaughter point were washed after singeing.

Even though zinc levels in all the hides of goat and sheep and even fresh unsinged hides were far higher than the maximum permissible value of 50 mgkg-1 (USDA, 2006; OJEC, 2001), at all the slaughter points used for this study, decreases were however recorded in all samples when singed hides were washed even though they still exceeded the maximum permissible value. Goat hides singed with vehicle scrap tyres and unwashed at the Jamestown slaughter point recorded the highest level of Zn 312.5±22.5 mg/kg and goat hides singed using LPG and unwashed at the Accra Abattoir recorded the lowest 133.85±10.35 mg/kg.

Even though no Pb was recorded in unsinged, singed unwashed and singed and washed goat and sheep hides at all points of slaughter, 0.0543±0.0067 ppm concentration of Pb was recorded in sampled water from the Jamestown slaughter point but not in water from the other slaughter points. Water used for washing of scrap tyre singed hides at the Jamestown slaughter point was collected from the sea just close to where all their meat processing effluent flows into the sea.

This could also have contributed to the results of heavy metal concentrations obtained in hides, singed and washed at the slaughter point. Water sampled from the Accra Abattoir recorded the lowest concentrations in analyzed metals and recorded no concentrations of Mn, Cu, Ni and Pb. It appears in this study that the substantial heavy metal levels especially Zn and Mg, in the fresh un-singed hides contributed considerably to the overall high values recorded in the singed hides. This seems to suggest that other factors such as rearing conditions of animals, depicted by the relatively high levels of the metals in control hides, have also accounted for the levels of heavy metals realized in the singed hides.

Similar findings were reported by Obiri-Danso *et al.* (2008) as unacceptable levels of Cd, Zn and Pb concentrations were found in un-singed hides prior to singeing with the vehicle scrap tyres as source of fuel, reflecting undue levels of heavy metal exposure in the local environment. Qui *et al.*, (2008) also established that there is a close relationship between heavy metal concentration in cattle tissue with that in the soil, feed and drinking water. Obiri-Danso *et al.*, (2008), reported zinc values of 17.71±3.48 mgkg-1 for un-singed hides which increased considerably to 204. 49±36.68 mgkg-1 after they were singed with vehicle scrap tyres as fuel. Zinc is essential for normal functioning of cells including protein synthesis, carbohydrate metabolism, cell growth and cell division (Cousins, 1996).

However, at very high concentrations it can depress the immune system, cause anaemia, copper deficiency and decrease high-density lipoprotein cholesterol in the blood (Black *et al.*, 1988).

With the exception of Pb and Cd that were not found in this study, the levels of metals reported in all the processed hides were generally as high as other reported cases of heavy metal concentrations in treated hides or “welle” and other meat products (Okiei *et al*., 2009; Obiri-Danso *et al*., 2008). Essumang *et al*., (2007) also reported elevated levels of 206.40 mg/kg, 245.80 mg/kg, 14.40 mg/kg and 6.00 mg/kg for iron, zinc, chromium and nickel respectively in singed hides processed with vehicle worn out tyres as fuel source.

The non-detectable levels of Pb and Cd in this study could be an indicator that animals were reared or herded quite far away from cities and towns where industrial waste, refuse dumps and incinerators serve as major sources of these metals. Eremong, (2011) also reported that in analyzing fermented, tyre singed, LPG singed and wood singed samples Cd and Pb were not detected in any of the samples before and after boiling. The permissible levels of Cd and Pb in meat are 0.05 mg/kg and 0.1 mg/kg, respectively (USDA, 2006; OJEC, 2001).

With regards to Mg, Mn and Ni, Lenntech, (2012) gives the daily toxic intake levels of Mg, Mn and Ni, as >400 mg,>5 mg and>1 mg, respectively, so it is unclear whether the high concentrations of these metals recorded in the goat and sheep hides may constitute a significant problem to meat consumers. As contaminants however, no MPL’s have been fixed for them in meat. This suggests that the concentrations of these metals are within safe limits if consumed in moderate amounts per day and may not constitute any toxicological concerns to the goat and sheep meat -consuming public in Ghana.In Ghana meat safety inspections and permitting, is carried out by state agencies to ensure that market meat is wholesome.

The Food and Drugs Law, 1992 (P.N.D.C.L. 305B) provides guidelines for the regulation of livestock products. All Metropolitan, Municipal and District Assemblies have slaughter houses and bye-laws that govern the production of meat in their jurisdiction.

Even though 65% of the butchers and workers at the Jamestown slaughter house had knowledge of the existence of the singeing Bye laws that stated that "No such body / butcher /marketer as licensed shall singe hides of carcasses using lorry tyres," they were not adhering to this bye law.

To encourage the wholesome processing of meat, the Accra Abattoir a state- of- the- art facility was built and equipped with necessary singeing logistics to replace the old slaughter house in Jamestown. In spite of this some butchers still prefer operating at the Jamestown slaughter point because of additional costs incurred in transporting animals to the Accra Abattoir and the physical exhaustion the animals experience travelling the distance to the Accra Abattoir. This has led butchers to resort to the use of vehicle scrap tyres as fuel as they cannot afford to buy the LPG singeing logistics themselves for their work at Jamestown. Butchers indulge in vehicle scrap tyre singeing regardless of the health implications it has on them and the consumers as well as flouting of the Law, because according to them it is cheaper, and this mode of singeing is faster.

Goat and sheep hides that have been singed using vehicle scrap tyres from the Jamestown slaughter point are sold in all major markets in the Accra Metropolis just like meat processed in a regulated Abattoir and consumers are most likely not able to tell whether they were buying meat that has been singed using LPG or vehicle scrap tyres as fuel.

This activity of singeing with vehicle scrap tyres as source of fuel at the Jamestown Slaughter site has been going on unnoticed by the watchful eyes of the authorities.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary and conclusion

The results of this study indicated that Pb and Cd were not present in any of the fresh unsinged, singed unwashed and singed and washed goat and sheep hides that were analyzed. However, Zn levels in all fresh unsinged goat and sheep hides analyzed were already above the MPL before singeing. The non-detection of Pb and Cd and the high concentrations of Zn in singed hides could not be entirely attributed to the singeing alone. This could be attributed to the animal rearing/environmental conditions (soil, pasture, water sources, medication, etc.) prevailing where the animals were reared; a situation that probably reflected a larger problem of heavy metal pollution in the local environment.

Slaughtered animals singed using Liquefied Petroleum Gas (LPG) as source of fuel recorded some elevations as well as losses in heavy metal concentrations, however, singeing the animals with vehicle scrap tyres as fuel source, recorded elevated heavy metal concentrations only, in the hides of both slaughtered goats and sheep. Slaughtered animals singed with vehicle scrap tyres as fuel source also recorded more heavy metals on the hides than those singed with LPG as fuel source. The levels of Mn and Cu generally increased in hides singed with vehicle scrap tyres.

The type of water used in washing singed hides also influenced concentration of metals in processed meat hides as water used from the different sources already contained varying concentrations of some heavy metals especially, sea water from the Jamestown slaughter point.

The greatest threat was presented by Zn, which far exceeded maximum permissible levels for meat; animals singed with vehicle scrap tyres as fuel source recorded the highest concentration

of levels of Zn in both goat and sheep hides. Processing of hides by burning with scrap tyres causes environmental pollution because of the toxic compounds released to the atmosphere.
Goat and sheep hides that have been singed using vehicle scrap tyres as fuel source are sold in all major markets in the Accra Metropolis and consumers are most likely not able to tell whether they were buying meat that has been singed with LPG or vehicle scrap tyres. Continuous consumption of the hides as meat product in Ghana might have significant health implications in view of the high heavy metal content.

The hides obtained from the Accra Abattoir were the safest amongst the analyzed hides as meat products for human consumption. The present study has been useful in laying emphasis on the health risks to which several meat processors and millions of consumers of the processed hides are exposed. The study underscores an urgent need to regularize the activities of local butchers in Ghana to conform to best practices necessary, as in abattoir operations.

6.2 Recommendations

- The Agricultural Extension Agents and Veterinary personnel should intensify their education of local farmers on the use and safe disposal of agricultural chemicals as these eventually find their way into the food chain and are ingested by the animals butchers slaughter for the consuming public.
- As most people do not know about the harmful presence of heavy metals in meat, health education of the public should be undertaken, by health institutions, educational bodies and regulatory bodies through print and electronic media to create awareness among the public.
- Political authorities must enforce available laws to protect public health, and also create an environment for animal processors to obey these laws,
- The Accra Metropolitan Assembly must ensure the availability of LPG all year round as source of fuel for meat processing and must provide financial subsidies to reduce the cost LPG for meat processors, thereby ensuring meat safety for consumers.
- The Veterinary Public health authorities, as well as the consuming public, must be actively engaged in advocating for safe meat processing practices.
- In order to ensure that the Maximum Permissible Levels of metals are not exceeded, routine surveillance of meat must be carried out, involving analysis of samples of potentially contaminated produce, followed by laboratory analysis to determine the levels of heavy metals in meat products.

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APPENDIX

Table 1: ANOVA-Unsinged Goat and Singed Unwashed Goat-Avenor

Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.6225	1	21.6225	1.2482320	0.3800964	18.5128205
Within Groups	34.645	2	17.3225			
Total	56.2675	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6480.25	1	6480.25	0.7657462	0.4738176	18.5128205
Within Groups	16925.3	2	8462.66			
Total	23405.5	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.84	1	4.84	0.0431969	0.8545976	18.5128205
Within Groups	224.09	2	112.045			
Total	228.93	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.2025	1	0.2025	1.9485E-05	0.9968787	18.512825
Within Groups	20785.565	2	10392.7825			
Total	20785.767	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	55.5025	1	55.5025	1.5293104	0.3417317	18.5128205
Within Groups	72.585	2	36.2925			
Total	128.087	3				

Table 2: ANOVA- Unsinged Goat and Singed Washed Goat- Avenor

Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	72.25	1	72.25	2.2748740	0.2705139	18.512820
Within Groups	63.52	2	31.76			
Total	135.77	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*

Between Groups	942.49	1	942.49	0.0542595	0.8374786	18.512820
Within Groups	34740.0	2	17370.02			
Total	35682.5	3				
Zinc (Zn)						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.49	1	0.49	0.0032639	0.9596352	18.5128205
Within Groups	300.25	2	150.125			
Total	300.74	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.2025	1	0.2025	0.0106508	0.9272179	18.512820
Within Groups	38.025	2	19.0125			
Total	38.2275	3				

Table 3: ANOVA- Unsinged Sheep and Singed Unwashed Sheep-Avenor						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.1225	1	0.1225	0.0333560	0.8719202	18.5128205
Within Groups	7.345	2	3.6725			
Total	7.4675	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	32364.0	1	32364.0	25.072733	0.0376461	18.5128205
Within Groups	2581.61	2	1290.80			
Total	34945.6	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.81	1	0.81	0.0527000	0.8397703	18.5128205
Within Groups	30.74	2	15.37			
Total	31.55	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1701.5625	1	1701.5625	1.7388566	0.3180343	18.512820
Within Groups	1957.105	2	978.5525			
Total	3658.6675	3				

Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.61	1	3.61	0.0793058	0.8047040	18.5128205
Within Groups	91.04	2	45.52			
Total	94.65	3				

Table 4: ANOVA-Unsinged Sheep and Singed Washed Sheep-Avenor

Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.25	1	6.25	1.122082	0.4004985	18.5128205
Within Groups	11.14	2	5.57			
Total	17.39	3				

Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	25892.02	1	25892.0	25.02733	0.0377106	18.5128205
Within Groups	2069.100	2	1034.55			
Total	27961.12	3				

Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.7225	1	2.722	0.208900	0.6924739	18.5128205
Within Groups	26.065	2	13.03			
Total	28.7875	3				

Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	95.0625	1	95.0625	0.090898	0.7914975	18.512820
Within Groups	2091.625	2	1045.8125			
Total	2186.6875	3				

Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0	1	0	0	1	18.5128205
Within Groups	7.84	2	3.92			
Total	7.84	3				

Table 5: ANOVA: Unsinged Goat and Singed Unwashed Goat -Jamestown						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	68.89	1	68.89	10.92624	0.08061103	18.51282051
Within Groups	12.61	2	6.305			
Total	81.5	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	19321	1	19321	2.706771	0.2416595	18.5128205
Within Groups	14276.05	2	7138.025			
Total	33597.05	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	31.36	1	31.36	3.954602	0.18506112	18.5128205
Within Groups	15.86	2	7.93			
Total	47.22	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7327.36	1	7327.36	1.9571672	0.2967305	18.512820
Within Groups	7487.72	2	3743.86			
Total	14815.08	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.89	1	2.89	0.526411	0.54353163	18.5128205
Within Groups	10.98	2	5.49			
Total	13.87	3				

Table 6: ANOVA- Unsinged Goat and Singed Washed Goat -Jamestown						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	119.9025	1	119.902	30.64600	0.0311157	18.5128205
Within Groups	7.825	2	3.9125			
Total	127.7275	3				

Magnesium (Mg)						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	197936.0	1	197936.0	20.40416	0.0456777	18.5128205
Within Groups	19401.53	2	9700.765			
Total	217337.5	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	37.822 5	1	37.8225	53.83985	0.0180716	18.5128205
Within Groups	1.405	2	0.7025			
Total	39.227	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3672.36	1	3672.36	0.956877	0.4311321	18.5128205
Within Groups	7675.72	2	3837.86			
Total	11348.08	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.49	1	0.49	0.099391	0.7824155	18.5128205
Within Groups	9.86	2	4.93			
Total	10.35	3				

Table 7: ANOVA-Unsinged Sheep and Singed Unwashed Sheep -Jamestown

Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.2025	1	4.2025	0.8917771	0.4446768	18.5128205
Within Groups	9.425	2	4.7125			
Total	13.6275	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	44184.0	1	44184.04	8.1955169	0.1034313	18.5128205
Within Groups	10782.4	2	5391.245			
Total	54966.5	3				

Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	25.5025	1	25.5025	2.4259215	0.2596509	18.5128205
Within Groups	21.025	2	10.5125			
Total	46.5275	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	29395.102	1	29395.10	11.462034	0.0772681	18.5128205
Within Groups	5129.125	2	2564.562			
Total	34524.227	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	35.40	1	35.402	1.5147074	0.3435225	18.5128205
Within Groups	46.74	2	23.372			
Total	82.14	3				

Table 8: ANOVA-Unsinged Sheep and Singed Washed Sheep-Jamestown						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	6.5025	1	6.5025	3.092746	0.2207153	18.5128205
Within Groups	4.205	2	2.1025			
Total	10.7075	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	191362.50	1	191362.5	48.70374	0.0199208	18.5128205
Within Groups	7858.225	2	3929.112			
Total	199220.72	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	67.24	1	67.24	14.291179	0.0633921	18.5128205
Within Groups	9.41	2	4.705			
Total	76.65	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	14665.21	1	14665.21	7.3494720	0.1133861	18.5128205
Within Groups	3990.82	2	1995.41			

Total	18656.03	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.5625	1	1.5625	0.5364806 9	0.5401022 7	18.5128205
Within Groups	5.825	2	2.9125			
Total	7.3875	3				

Table 9: ANOVA-Unsinged Goat and Singed Unwashed Goat -Accra Abattoir						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.1225	1	0.1225	0.0861159	0.7968238	18.5128205
Within Groups	2.845	2	1.4225			
Total	2.9675	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	16371.202	1	16371.20	1.4517129	0.3514805	18.5128205
Within Groups	22554.325	2	11277.16			
Total	38925.527	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.25	1	2.25	3.9823008	0.1841075	18.5128205
Within Groups	1.13	2	0.565			
Total	3.38	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1066.0225	1	1066.022	6.6455076	0.1232640	18.5128205
Within Groups	320.825	2	160.4125			
Total	1386.8475	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9.3025	1	9.3025	12.875432	0.0696505	18.5128205
Within Groups	1.445	2	0.7225			
Total	10.7475	3				

Table 10: ANOVA-Unsinged Goat and Singed Washed Goat -Accra Abattoir						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1	1	1	0.754716	0.476576	18.512820
Within Groups	2.65	2	1.325			
Total	3.65	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20836.922	1	20836.92	1.933300	0.298914	18.512820
Within Groups	21555.805	2	10777.90			
Total	42392.727	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.0625	1	5.0625	7.758620	0.108342	18.512820
Within Groups	1.305	2	0.6525			
Total	6.3675	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.04	1	0.04	6.0749E-05	0.994488	18.512820
Within Groups	1316.9	2	658.45			
Total	1316.94	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.1225	1	0.1225	0.0711175	0.81469	18.512820
Within Groups	3.445	2	1.7225			
Total	3.5675	3				

Table 11: ANOVA-Unsinged Sheep and Singed Unwashed Sheep -Accra Abattoir						
Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5.5225	1	5.5225	2.357524	0.264457	18.51282
Within Groups	4.685	2	2.3425			
Total	10.2075	3				

Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	5343.61	1	5343.61	1.097656	0.404726	18.51282
Within Groups	9736.4	2	4868.2			
Total	15080.01	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	22.09	1	22.09	0.248035	0.667834	18.51282
Within Groups	178.12	2	89.06			
Total	200.21	3				
Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1017.2910	1	1017.291	0.958698	0.430766	18.51282
Within Groups	2122.2342	2	1061.117			
Total	3139.5252	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	12.1801	1	12.1801	0.382876	0.599153	18.51282
Within Groups	63.6242	2	31.8121			
Total	75.8043	3				

Table 12: ANOVA-Unsinged Sheep and Singed Washed Sheep -Accra Abattoir

Manganese (Mn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.25	1	20.25	20.98446	0.044498	18.51282
Within Groups	1.93	2	0.965			
Total	22.18	3				
Magnesium (Mg)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	31493.82	1	31493.83	2.331627	0.266325	18.51282
Within Groups	27014.46	2	13507.23			
Total	58508.29	3				
Copper (Cu)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	64.3204	1	64.3204	0.856778	0.452359	18.51282
Within Groups	150.1448	2	75.0724			
Total	214.4652	3				

Zinc (Zn)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1106.2276	1	1106.228	1.090595	0.405967	18.51282
Within Groups	2028.6676	2	1014.334			
Total	3134.8952	3				
Nickel (Ni)						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.030625	1	0.0306	0.000689	0.981443	18.51282
Within Groups	88.90065	2	44.450			
Total	88.93127	3				

QUALITATIVE SURVEY

Table 13: Factors that determine method of singeing used

Factors	**Frequency**	**Percent (%)**
Cost	4	20.0
Material availability	2	10.0
Consumer preference	5	25.0
Ease and speed of process	9	45.0
Total	**20**	**100.0**

Table 14: Butchers Knowledge of the existence of laws governing singeing in Ghana

Response	**Frequency**	**Percent (%)**
Yes	13	65.0
No	7	35.0
Total	**20**	**100.0**

Table 15: Factors that will influence Butchers' Adoption of a safe singeing method

Factors	**Frequency**	**Percent (%)**
Awareness creation of health implications	1	5.0
Subsidization of LPG	6	30.0

Provision of Singeing logistics	2	10.0
Availability of LPG	6	30.0
Provision of an Abattoir	3	15.0
Personal Safety	2	10.0
Total	**20**	**100.0**

Table 16: Avenor slaughter point (LPG singeing)

Parameters (mg/kg)		**Unsinged Goat**	**Singed Unwashed Goat**	**Singed Washed Goat**	**Unsinged Sheep**	**Singed Unwashed Sheep**	**Singed Washed Sheep**
Mn	Mean	20.7	16.05	12.2	8.1	8.45	5.6
	SEM	±2.6	±3.25	±5	±1.9	±0.25	±1.4
Mg	Mean	697.5	778	728.2	422.05	601.95	582.96
	SEM	±82.1	±41.5	±103.1	±28.05	±22.45	±15.74
Cu	Mean	13.65	11.45	12.95	7.3	6.4	5.65
	SEM	±9.65	±0.65	±1.45	±3.1	±2.4	±1.85
Zn	Mean	185.55	186	184.55	146	187.25	155.75
	SEM	±90.15	±47.6	±12.85	±30.5	±6.95	±10.15
Ni	Mean	14.75	22.2	15.2	14.2	16.1	17.8
	SEM	±1.95	±5.7	±3.9	±1.4	±6.6	±0.2
Pb		ND	ND	ND	ND	ND	ND
Cd		ND	ND	ND	ND	ND	ND

ND: Not Detected

Table 17: JAMESTOWN

Parameters (mg/kg)		**Unsinged Goat**	**Singed Unwashed Goat**	**Singed Washed Goat**	**Unsinged Sheep**	**Singed Unwashed Sheep**	**Singed Washed Sheep**
Mn	Mean	6.45	14.75	17.4	3.55	5.6	1
	SEM	±0.55	±2.45	±1.9	±1.05	±1.9	±1
Mg	Mean	528.35	667.35	973.25	482.85	693.05	920.3
	SEM	±62.95	±56.35	±75.75	±57.35	±45.85	±25.3
Cu	Mean	5.3	10.9	11.45	3.55	8.6	11.75
	SEM	±0.8	±2.7	±0.25	±0.95	±3.1	±1.95
Zn	Mean	226.9	312.5	287.5	126.8	298.25	247.9
	SEM	±56.9	±22.5	±24.5	±43	±26.75	±12.1
Ni	Mean	12	13.7	12.7	11.8	17.75	13.05
	SEM	±1.8	±1.5	±1.3	±0.9	±4.75	±1.45

Pb		ND	ND	ND	ND	ND	ND
Cd	Mean	ND	0.005	ND	ND	0.0015	ND
	SEM		±0.001		0	±0.0015	0

ND: Not Detected

Table 18: ACCRA ABBATOIR							
Parameters (mg/kg)		**Unsinged Goat**	**Singed Unwashed Goat**	**Singed Washed Goat**	**Unsinged Sheep**	**Singed Unwashed Sheep**	**Singed Washed Sheep**
Mn	Mean	3.15	3.5	2.15	4.75	2.4	0.25
	SEM	±0.65	±1.0	0.95	±0.95	±1.2	0.25
Mg	Mean	611.4	739.35	755.75	540.2	613.3	717.665
	SEM	±102.2	±28.85	±18.25	±51.2	±47.4	±104.335
Cu	Mean	4.95	3.45	2.7	13.5	8.8	5.48
	SEM	±0.75	±0.05	±0.3	±8.5	±4.1	±1.68
Zn	Mean	101.2	133.85	101.4	115.33	83.435	82.07
	SEM	±7.3	±10.35	±24.6	±29.05	±13.665	±11.83
Ni	Mean	16.7	19.75	13.35	19.61	23.1	19.435
	SEM	±0.4	±0.75	±1.75	±2.61	±5	±6.135
Pb		ND	ND	ND	ND	ND	ND
Cd		ND	ND	ND	ND	ND	ND

ND: Not Detected

Table 19: Percentage Increase In Metal Concentrations In Singed Hides Relative To Controls						
HEAVY METALS	**AVENOR SLAUGHTER POINT**		**JAMESTOWN SLAUGHTER POINT**		**ACCRA ABATTOIR**	
	Goats Hide (%)	Sheep Hide (%)	Goats Hide (%)	Sheep Hide (%)	Goats Hide (%)	Sheep Hide (%)
Mn	*23.16	4.32	128	57	11	*49.47
Mg	11.54	42.63	26.3	43.53	20.95	13.53
Cu	*16.12	*12.33	105.66	142.25	*30.30	*34.81
Zn	0.21	28.25	37.73	135.21	32.06	*27.66
Ni	50.51	13.38	14.17	50.42	18.26	17.8
Pb	ND	ND	ND	ND	ND	ND
Cd	ND	ND	0.005	0.002	ND	ND

ND: Not Detected

*Percentage Decrease

Table 20: WATER SAMPLES				
Parameters (mg/kg)		**JAMESTOWN WATER**	**AVENOR WATER**	**ACCRA ABATTOIR WATER**
Mn	Mean	0.0033	0.279	ND
	SEM	±0.001	±0.018	
Mg	Mean	675.367	61.13	14.75
	SEM	±32.26	±3.43	±0.66
Cu	Mean	ND	ND	ND
	SEM	-	-	-
Zn	Mean	0.015	0.0393	0.154
	SEM	±0.004	±0.036	±0.006
Ni	Mean	0.208	0.066	ND
	SEM	±0.006	±0.009	
Pb	Mean	0.0543	ND	ND
	SEM	±0.0067	-	-
Cd	Mean	0.13	0.035	0.034
	SEM	±0.017	±0.006	±0.007

ND: Not Detected

Table 21: Coordinates of Primary Sales Points

Location Names	**West**	**North**
Avenor Slaughter point	-0.21851	5.57573
Accra Abattoir	-0.06922	5.6608
Jamestown Slaughter point	-0.21437	5.53226
Kaneshie Market	-0.23702	5.56632
Mallam Atta Market	-0.20835	5.57943
Makola Market	-0.20611	5.54962
Salaga Market	-0.20916	5.54014
London Market	-0.21533	5.53733
Dome Market	-0.23732	5.64407
Lapaz Market	-0.25628	5.60902
Nima Market	-0.19844	5.58074

QUESTIONNAIRE

DEPARTMENT OF ENVIRONMENTAL SCIENCE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLGY

Topic: An Assessment of the Distribution of Meat Contaminated by Singeing from Slaughter point to Sales point using a Geographic Information System: Case Study of some Slaughter Points.

Attached is a questionnaire on the above topic please be assured that this is for purely academic purpose and any information you provide will be treated with strict confidentiality.

Section A: background information

(Please tick the appropriate answer)

1. Gender:

a. Male [ ]

b. Female [ ]

2. Age:

a. 11-20yrs [ ]

b. 21-30yrs [ ]

c. 31-50yrs [ ]

d. 51yrs or more [ ]

3. How long have you been slaughtering animals at this Jamestown Beach?

a. 1yr and below [ ]

b. 2yrs [ ]

c. 3yrs [ ]

d. 4yrs [ ]

e. 5yrs or more [ ]

4. What is your Educational level Attained?

a. O/A or SSCE Level [ ]

b. Diploma [ ]

c. HND [ ]

d. Degree [ ]

e. Other (please specify)…………………………………………

Section B (Slaughtering Operations)

1. How many days of the week do you work here? a. 1 to 2 days [ ] b. 3 to 5 days [ ] c. More than 5 days [ ]	2. Which Animals do you slaughter? a. Cattle [ ] b. Sheep [ ] c. Goat [ ]	3. How many animals do you slaughter per day? a. 1 to 3 [ ] b. 4 to 6 [ ] c. 7 to 9 [ ] d. above 9 [ ]

4. After slaughtering how is fur removed from animal? a. Skinning **A** b. Singeing **B** c. Other Specify………………	5. If singeing, what materials are used for the process? a. Tyres [ ] b. Firewood [ ] c. Tyres and Firewood [ ] d. Gas (LPG) [ ] e. Other Specify……………….	6. What determines singeing process used? a. cost [ ] b. availability of material [ ] c. consumer preference [ ] d. Process used by all [ ] e. Other Specify…………………
7. What is your main source of water for slaughtering operations? a. Seawater [ ] b. Pipe [ ] c. Bore hole/well [ ] d. Water Tanker [ ] e. Other Specify………………	8. How do you dispose of your waste? a. Into the Sea [ ] b. Buried on the Beach [ ] c. Waste Skips [ ] d. Other Specify………………	9. Which Clients do you supply meat to? (tick all that apply) a. Meat Sellers at the Market **A** b. Meat Sellers Elsewhere **B** c. Chop bar operators **C** d. Institutional canteens (schools) **D** f. Restaurants **F** e. Other Specify……………… **G**
11. In which communities can your clients /customers be found? (please write) a. ………………………………. b……………………………. c. …………………………….. d. ………………………………. e………………………………	14. Do you know of laws in Ghana that are against tyre singeing procedure for meat? a. Yes [ ] b. No [ ]	16. What would make you adopt a safe singeing method? a. Awareness creation **A** b. Subsidized fuel **B** b. Provision of singeing logistics **C** c. Provision of an Abattoir **D** d. Other Specify……………………………