KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST)

METAL AND NUTRIENT COMPOSITION OF PROCESSED CATTLE HIDE (WELLE) USING FOUR PROCEDURES

BY

DABUO CEPHAS, EREMONG

BSc. AGRICULTURE TECHNOLOGY (HONS) UDS

TAMALE, GHANA

THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KNUST IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE MASTER OF SCIENCE (MEAT SCIENCE) DEGREE

JULY 2011

DECLARATION

I do declare that this thesis has not been submitted for a degree to any other University, hence this work is entirely my own account of the research

Name of student: DABUO CEPHAS, EREMONG

(PG 1747507)

Signature: ……………………………

Date: ………………………………

Name of Supervisor: Prof. A. Donkoh

Signature: ………………………………

Date:………………………………………..

Name of co-supervisor: Mr W.Y. Akwetey

Signature: …………………….

Date: …………………………..

DEDICATION

To my dear wife Vivian and children, Cedrick and Garvey

ACKNOWLEDGEMENTS

I would first of all give thanks and praises to Almighty God for granting me the gift of patience, wisdom, grace and guidance throughout the study.

I wish to express my profound gratitude to my supervisor Prof. A. Donkoh for his facilitation and making it possible to see me through this programme.

I am deeply indebted to Mr. Worlah Akwetey, a lecturer at the Department of Animal Science and co-supervisor of this work, for his valuable criticisms, suggestions and guidance during the period of study.

I am also grateful to Mrs Victoria Attoh-Kotoku, a Lecturer and Prof. D.B Okai for their interest in this study. They were great sources of motivation and encouragement to me especially during challenging times.

I also wish to express my sincere gratitude to the staff of the Chemistry Department, Ghana Atomic Energy Commission (GAEC), Accra for the chemical analysis of the samples. My special thanks go to Mr. Nash Owusu, Bentil the Senior Technician of the unit for his cordiality and humility.

I am also grateful to Dr. Alfred Arthur of Cocoa Research Institute, Tafo and Emmanuel Ayipio of Savanna Agricultural Research Institute for their invaluable assistance in the statistical analyses of the data.

Finally I appreciate immensely the encouragement given me by my wife and children during the period of study.

ABSTRACT

This study was carried out to determine the concentrations of essential and some heavy metals (Fe, Mn, Cu, Zn, Pb and Cd) in dehaired cattle hides 'Welle' processed by means of fermentation, firewood, scrap motor tyre and liquefied petroleum gas (LPG) as fuel for singeing. The nutrient composition (crude protein, ether extract and ash) of 'welle' was also evaluated. The concentrations of the metals were measured by atomic absorption spectrophotometry (AAS) and reported as mg/kg dry weight of dehaired cattle hides. The levels of heavy metals in the fermented and singed samples (wood, tyre and LPG) ranged from 73.13 to 264.14 mg/kg Fe; 5.84 to 40.04 mg/kg Mn; 0.19 to 20.31 mg/kg Cu; 3.29 to 35.31 mg/kg Zn; <0.001 mg/kg Pb; and <0.002 mg/kg Cd. Generally, the fermented treatments recorded the highest significant levels (p<0.05) of metals compared to the singed treatments. Cu slightly exceeded the maximum permissible limit (MPL) in the fermented, washed and boiled samples. . There were also significant differences (p<0.05) among the fermented washed and boiled, wood-singed washed and boiled, tyre-singed washed and boiled, and LPG-singed washed and boiled samples with respect to their metal contents. The singed samples were relatively high in their contents of Fe with moderate amounts of Zn, Mn and Cu. However, the concentrations of Fe and Mn in this study cannot be described as contaminants as there is no MPL fixed for them in animal food sources. The contents of Pb and Cd were below detectable limits Processing methods significantly (p<0.05) influenced the crude protein (CP), ether extract (EE) and ash contents of 'welle'. Crude protein values for fermentation (93.60), tyre (92.03) and wood (90.37) were significantly (p<0.05) different from liquefied petroleum gas (LPG) (85.6O). There was also significant (p<0.05) difference in ash values between fermented (1.67), LPG (1.17), and wood-singed 'welle' With respect to EE values there were significant difference among all treatment means. The LPG-singed "welle" recorded

the highest value of 11.67 followed by wood (7.17), tyre (4.67) and fermentation (4.0).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE **PAGE**

LIST OF ABBREVIATIONS

ACS	-	American Chemical Society
AMS	-	Agricultural Marketing Services
APVMA	-	Australian Pesticides & Veterinary Medicine Authority
ASNS	-	American Society for Nutritional Science
ASQC	-	American Society for Quality Control
ATSDR	-	Agency for Toxic Substances & Disease Registry
BCWG	-	Base Convention Working Group
CAR	-	Clean Air Revival
CHC	-	Canadian Health Coalition
CHD	-	Chronic Heart Disease
CIWMB	-	California Integrated Waste Management Board
CVD	-	Cardio – Vascular Disease
CWFT	-	Compassion in World Farming Trust
ECR	-	European Commission Regulation
FAD	-	Food and Agricultural Development
FAO	-	Food & Agriculture Organization
FDA	-	Food & Drug Administration
FSANZ	-	Food Standard of Australia & New Zealand
GEPC	-	Ghana Export & Promotion Council
GMIA	-	Gelatin Manufactures Institute of America
IAFC	-	International Association of Fire Chiefs
ICT	-	International Council of Tanners
IFF	-	Internationale Forschungsgemeinschaft Futtermitteltechnik
LWTPH	-	Lentech Water Treament & Purification Holding
MAFF	-	Ministry of Agriculture, Fisheries and Food
MFPO	-	Meat Food Product Order

MTPSI		Ministry of Trade& Presidential Special Initiative
NFPA	-	National Fire Protection Association
NOAH	-	National Office of Animal Health
NRSAR	-	National Residue Survey Annual Report
NRSAR	-	National Residue Survey Annual Report
NZSA	-	New Zealand Food Safety Authority
OCES	-	Oklahoma Co-operative Extension Services
ODS	-	Office of Dietary Supplements
OECD	-	Organization for Economic Co-operation & Development
OJEC	-	Official Journal of European Communities
QFAC	-	Quest for Advance Condition
RDI	-	Recommended Daily Intake
SCVMPH		Scientific Committee on Veterinary Measures Relating to Public Health
STMC	-	Scrap Tyre Management Council
TPM	-	Toxicological Profile for Manganese
USDA	-	United States Department of Agriculture
USEPA	-	United States Environmental Protection Agency
USFA	-	United States Fire Administration
VSD	-	Veterinary Services Directorate
WHO	-	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

The rise in population as well as increased affluence in many countries have led to increasing demand for animal products which has reflected in the rapidly growing livestock industry in most countries. Since 1960, global meat production has more than trebled, milk production nearly doubled and egg production increased by nearly four times (Speedy, 2003). In general lean meat is particularly a good source of protein, niacin, vitamins B_6 and B_{12}, phosphorous, zinc, and iron with 100g of lean meat providing more than 25% of the recommended daily intake (RDI) of protein (Williams, 2007). Animal proteins, as indicated by Ziegler (1968) have a high biological value, and the presence of essential amino acids in meat makes it a complete protein (Bastin, 2007).

Processed cattle hide popularly known as "ponmo" in South-Western Nigeria, and 'welle' in Southern Ghana are served as food delicacy in several parts of Africa (Okiel *et al.*, 2009; Obiri-Danso *et al.*, 2008). Removal of the hair from the hides is traditionally done by tenderizing the hides in hot water followed by shaving with razor blade to give the finished product "ponmo" (Okiel *et al.*, 2009). In Ghana slaughtered ruminants such as goats, sheep, and cattle are normally singed to get rid of the fur. According to FAO (1985), singeing is largely favoured in many respects in African countries as it maintains the carcass hide for consumption and evokes flavours that are highly acceptable in meat by the local populace. Traditionally, singeing proceeds on open fire using firewood as fuel. However, the relative scarcity of firewood in recent times has resulted in local butchers using scrap tyres Obiri-(Danso *et al.*, 2008) and substances such as wood mixed with spent engine oil, plastics mixed with refuse or tyres (Okiel *et al.*, 2009). These materials contain potentially toxic substances which can contaminate the hides and render them unfit for human consumption (USFA, 1999; Obiri-Danso *et al.*, 2008; Okiel *et al.*, 2009).

Hides processed with flame fuelled by firewood and spent engine oil may contain toxic organic compounds such as furans and benzene. Lead, a highly toxic metal present in spent engine oil, can contaminate the hides. Dioxin released during wood burning is a potential carcinogen implicated in extreme skin diseases (USEPA, 1994; ATSDR, 1998). The burning of tyres releases environmental pollutants which contain hazardous substances such as styrene and 1, 3-butadienes (Holder *et al.*, 1991; Reisman, 1997; IAFC, 2000). Tyres also contain several metals such as lead, mercury, cadmium, chromium, zinc and arsenic which could contaminate hides when tyres are used as source of fuel (IAFC 2000; Pechan and Associate 1997; Organization for Economic Cooperation and Development (OECD), 2004). The continuous consumption of such potentially contaminated meat products poses a great source of health risk (Costa, 2000; Jayasekara *et al*. 1992; Leita *et al*. 1991). Moreover, the release of hazardous emissions associated with the burning of tyres, plastics and spent engine oil puts processors at risk through inhalation of these toxic compounds.

It is against this background that this study seeks to investigate the levels of heavy metals in cattle hides processed through various methods and the nutrient composition of 'welle' in order to assess their suitability for human consumption.

The specific objectives of this study include;

(1) Determination of levels of Fe, Mn, Zn, Cu, Pb and Cd in 'Welle' produced using;

a. fermentation (F),

b. singeing with wood (W),

c. singeing with scrap motor tyre (T),

d. singeing with liquefied petroleum gas(G).

(2)Establishment of the proximate components of ‘welle’.

(3) Determining the best production method for ‘welle’ that will offer better nutritional benefits to consumers.

CHAPTER TWO

LITERATURE REVIEW

2.1 MEAT

The Food Standard of Australia and New Zealand (FSANZ) 2002, Code defines meat as the whole or part of any buffalo, cattle, deer, pig, poultry, rabbit or hare, slaughtered other than in a wild state. This definition does not include eggs or fetuses.The term 'meat' refers only to meat flesh (skeletal muscle plus any attached muscle connective tissue or fat), but the FSANZ definition also includes offals (i.e. meat other than meat flesh, including brain, heart, kidney, liver, pancreas, spleen, thymus, tongue and tripe), and excludes bone marrow.

Meats are often referred to as red or dark and white meat. Red meat is mainly made up of muscles with fibres that are called slow fibres because they are used for extended periods of activity, such as standing or walking, and need consistent energy source. This energy is derived from fat cells which require oxygen for constant activity (Othman, 2006). For example, grazing cattle do not often make sudden movements, so much of their muscle is red.

White meat is made up of muscles with fibres that are called fast fibres, because they are used for quick burst of activity such as fleeing from danger. White meat, as in fish, has a translucent "glassy" quality when in the raw state. Meat from animals, such as calves and pigs, are categorized as white meat (Othman, 2006) and the myoglobin content is low in these muscles.

According to Williams, *et al.* (2002) red meat contains high BV proteins and important micronutrients, as well as essential Omega-3 polyunsaturated fats that are needed for good health throughout life. Williams (2007), indicated that though the nutritional composition of red meats may vary somewhat according to breed, feed regime, season and meat cut, in general lean red meat has a relatively low fat content, moderate in cholesterol and rich in protein and many essential vitamins and minerals.

2.2 NUTRIENTS IN MEAT

Nutrients are components of food that nourish the body. Whitney and Cataldo (1983) defined a nutrient as a substance obtained from food that is used in the body to promote growth, maintenance, and/ or repair. In order to function, the human body must have both macro-and micro-nutrients. Macronutrients include carbohydrates, proteins and fats that make the bulk of our diets whereas micronutrients are vitamins and minerals that make up the smaller, but equally essential part (Parley International, 1996). It further stated that protein is the most abundant (75%) solid material in the body and, that animal foods such as meat, fish, poultry, milk, and eggs are rich in protein.

Lawrie (1991) indicated that though meat is a very good source of essential amino acids, vitamins, minerals and essential fatty acids, it is not usually relied upon for vitamins and essential fatty acids in a well-balanced diet. However, Cross and Overby (1988) indicated that organ meat, such as liver is a valuable source of vitamins A, B1 and nicotinic acid. It was also stated that macronutrients make up more than 98% of edible portion in meat.. Lean meat is defined as meat containing very high amount of protein, water and very little fat thus providing no more than 120 kcal/100kg (Cross and Overby, 1988). In Germany, most consumers demand lean meat (LM) from which all subcutaneous and intramuscular fat have been removed. The approximate composition and energy content of lean meat from different slaughter animals are illustrated in Table 1.

Table 1: Comparison of lean meat (LM) from different slaughter animals.

Slaughter Animal	Nutrient					
	Water g/(100g)	Protein g/(100g)	Fat g/(100g)	Carbohydrates g/(100g)	Minerals g/(100g)	Energy kcal (KJ)
Pigs	74	23	2	-	1	113(471)
Young bulls	74	22	2	_	1	110(460)
Calves	77	21	1	-	1	95(398)
Lambs	75	21	3	-	1	113(474)
Chicken	75	21	3	-	1	113(474)
Turkeys	75	21	3	-	1	113(474)

Source; Cross and Overby, (1988)

Amino acids are the basic units of proteins and their composition may vary slightly with species. With respect to the essential amino acids, beef appears to have relatively higher content of leucine, lysine and valine than pork or lamb but has lower content of threonine. The quality or biological value of a protein is determined by how closely its amino acid composition meets the body requirements. Quantitatively, the amino acids needed in greatest amounts for growth are arginine, lysine, leucine, phenylalanine and tyrosine (Lawrie, 1991). Ziegler (1968) described the biological value of meat protein as complete and added that, the body requirements for certain amino acids, of which at least ten are essential to life, are all present in meat. Though many kinds of vitamins are detectable in all meats, the amount of a particular vitamin differs considerably with respect to the type of meat and /or vitamin and depends on whether the meat is cooked or raw. Fat soluble vitamins A and D are nearly absent in lean meat of animals , but the liver is particularly rich in vitamin A and ascorbic acid (Vitamin C) which is detectable in

LM in relatively small amounts in comparison with fruits and vegetables (Cross and Overby, 1988). Organ meats, in general are richer in iron, copper and certain B vitamins, than lean meat. According to Bender and Zia (1976) and Cross and Overby (1988) liver is particularly rich in vitamins A, B_1, B_2, B_6 B_{12}, niacin and pantothenate.

Fat is the sum of many different components including glycerol and cholesterol as well as saturated mono-unsaturated and poly-unsaturated fatty acids each of which varies chemically and has different effects on health. The mono-unsaturated fatty acids of significance in meat are palmitoleic and oleic acids. The unsaturated fatty acids, linoleic, linolenic and arachidonic are essential as they are necessary constituents of cell walls, mitochondria and other intensively active metabolic sites. The body cannot produce these unsaturated fatty acids unless one of them is available in the diet (Lydia *et al.,* 2002). They also stated that, there is no evidence indicating that unsaturated fatty acids exert negative influence on blood cholesterol, but rather decrease the level of cholesterol in the blood. However it was emphasized that saturated fatty acids could have negative repercussions on blood cholesterol level. As illustrated in Table 2, game meats, bison and beef have larger quantities of mono-unsaturated fatty acids than myristic and palmitic acids, though game meats tend to be higher in Omega -6 poly-unsaturated fatty acid (linoleic and arachidonic acids) than bison and beef. Omega-6 poly-unsaturated fatty acids are common in diets and researchers have noted that their inclusion helps lower blood cholesterol (Lydia *et al.,* 2002).

Fish and fish oils are the major sources of Omega -3 poly-unsaturated fatty acids, even though they are found in low concentration in meat tissue (Lawrie, 1991; Lydia *et al.*, 2002). The rarity of coronary thrombosis among Greenland Eskimos, despite their very high intake of fat and cholesterol has been associated with the abundance of omega-3 poly-unsaturated fatty acids in fish (Lawrie, 1991).

Table 2: Fatty acids composition in mg/ 100g of meat in some game and farmed animals.

Fatty Acid (mg/100g)	Type of Animal					
	Pronghorn antelope	Mule deer	Elk	Bison	Range graze beef	Grain-fed beef
Saturated[b]	875	972	664	421	933	2028
Stearic	441	401	172	197	327	651
Myristic,Palmitic	434	571	492	224	606	1377
Mono-unsaturated[c]	582	732	508	444	754	2114
Poly-unsaturated[d]	530	463	399	182	191	291
Omega-6[e]	442	359	343	156	139	275
Omega [f]	88	104	56	26	52	16

Source; (Lydia *et al.*, 2002)

[a]Uncooked, lean only [b]Myristic, palmitic and stearic acids

[c]Palmitoleic and oleic acids [d]Linoleic arachidonic and linolemic acids

[e]Linoleic and arachidonic acids [f]Linoleic acid.

2.2.1 Nutrients in Variety Meats

Variety meats are by-product of non-skeletal muscle origin. These include edible organs such as livers, skin, bone marrow, kidneys and lungs. Organ meats or variety meats are composed somewhat differently from muscle meats with respect to macronutrients. The liver is a good source of energy and proteins followed by kidney and spleen, whilst lungs and blood are poor sources of energy, but are relatively high in water content (Aberle *et al.*, 2001).

Processed cattle hide popularly called ‘ponmo’ in South-Western Nigeria and ‘welle’ in Southern Ghana, a by-product of the meat industry is served as a delicacy in several parts of Africa (Okiel *et al.*, 2009). However, its nutritional composition/value is not well defined. Ofori, (2001) indicated that ‘ welle’ contains approximately 1.23 to 3.58 % fat, 56.46to 69.19 % protein and 1.33 to 1.94 % ash.

Variety meats are potential sausage ingredients and are often used in cooked sausage manufacture. It is evident that sausages that contain variety meats have an equivalent and frequently a superior nutritional value to those containing only skeletal muscle meats and thus meat inspection regulation require sausages containing these meat ingredients to be clearly labeled (Aberle *et al.*, 2001). Lawrie (1991) indicated that the titre of linoleic acid is markedly greater in lean meat of pigs than that of either ox or sheep and that such species differences are also reflected in the composition of the kidney and liver. In all the three species, the liver is a particularly rich source of polyunsaturated fat. Crawford (1975) emphasized that brain has a uniquely high content of C22 polyunsaturated acids which are essential for brain development especially in the foetus. However, it was indicated that the concentration of cholesterol in offal (particularly brain) is very much greater than in muscular tissue.

2.2.2 Nutritional Importance of Meat in Human Diet

Beef, pork, fish and other meats when consumed in moderation and combined with whole grains vegetables and fruits offer more than just different flavours but improve the nutritional value of the meal. According to Bill, (2010) depriving the body of meat's healthy ingredients puts one's well-being at risk.

Baghurst *et al.* (2000) indicated that red meat is a significant contributor of essential nutrients in the Australian diet including iron, zinc, protein and vitamin B_{12} and the second greatest contributor of omega-3 in the Australian diet, after fish. Holland (2011) reported that, a 3 oz serving of red meat supplies about half the protein an adult needs in a daily diet. Proteins serve as building materials for the growth, development and repair of body tissues (Bastin, 2007). Animal protein being a complete protein (Bastin, 2007) and therefore having a relatively higher biological value compared to other sources such as beans and whole wheat is vital in the diet of man (Ziegler, 1968). While it is clear that a good number of vegetarians eat nutritionally adequate diet (Southgate, 1978), the inclusion of animal products makes it easier to ensure a good diet (Lawrie, 1991). According to McAlpine (2011), the ODS reported that iron deficiency anaemia is the most common nutritional deficiency in the world. Iron found in red meat is termed haem iron which is more easily used by the body than non-haem iron the form of iron found in plants (Tremblay, 2011). Cross and Overby (1988) also stated that there is the need for meat protein in the diet of those people who suffer from marginal iron or calcium deficiency. The FAD/WHO (1985) reported that the human protein requirements are currently estimated to be 55g and 45g per day for both adult man and woman respectively. However, they recommended that daily protein intake of a person should be 1g per kg body weight and it is desirable that 50 % of this intake be animal proteins. The quality of a protein is a measure of its ability to satisfy human requirements for amino acids. Many animal sources have a Net Protein Utilization NPU (a measure of the usefulness of the protein to the body) around 0.75 while that of most plant foods is 0.5 to 0.6. Meat is a relatively concentrated source of high quality protein with an NPU value of 0.75 to 0.8 (about 95 % digestible compared with 80 % to 90 % for many plant foods) and it supplies a relative surplus of one essential amino acid, lysine, which is in relatively short supply in most cereals (FAO, 1992). When energy intake is inadequate some dietary protein is diverted from tissue synthesis to supply energy for general physical activity especially during food shortage and disease states when food is incompletely absorbed and utilized (FAD/WHO, 1985). Meat and meat products are important sources of all the B-complex vitamins including thiamin riboflavin, niacin, biotin, vitamin B_6 and B_{12}, pantothenic acid and folacin and higher intake of them is therefore recommended for patients at the convalescent stages (FAO, 1992).

Red meat is an excellent source of bioavailable vitamin B_{12}, providing over 2/3 of the daily requirement, as well as, 25% of the recommended daily intake (RDI) of riboflavin, niacin, vitamin B_6 and pantothenic acid in a 100g serve; but compared with pork, it is relatively a poor source of thiamin. Beef and lamb are among the richest sources of iron and zinc, with a 100g portion providing at least 1/4 of daily adult requirement. Meat protein also appears to enhance the absorption of iron and zinc from plant foods (Williams, 2007).

2.3. MEAT CONSUMPTION AND HEALTH ISSUES

A joint IFPRI/FAO/ILRI study suggested that global production and consumption of meat and other animal source foods (ASF) will continue to rise from 233 million metric tons (Mt) in 2000 to 300 million Mt in 2020 as will that of milk from 568 to 700 million Mt over the same period (FAO, 2003).

Although there is a great rise in global livestock production, the pattern of consumption is very uneven (Speedy, 2003), and is based largely on availability, price and tradition (Pearson and Dutson, 1990). In the US meat consumption is 124kg/capita/year, compared to the global average of 38 kg. The countries that consume the least of meat are in Africa and South Asia where consumption is between 3 and 5 kg/capita/year (Speedy, 2003). In Bangladesh, India and Sri Lanka, this is compensated for by higher fish (17.5 kg) and milk (47.5 kg and 35.9 kg) consumption respectively. In Ghana the per capita consumption of meat is 9.2 kg which is supplemented by a relatively higher intake of fish (26.2 kg/capita/year) (FAO, 2003; ASN, 2003).

About 50% of humans die from CVD in the developed western countries. Saturated fat and cholesterol content of meat and meat products are implicated and are considered 'risk factors' (RF) for the occurrence of CVD/CHD (Cross and Overby, 1988; Pearson and Dutson, 1990). For this reason, numerous official and or private authorities urge western populations to consume only small amounts of animal fat and less cholesterol. The recommendation of about 30 % fat in the entire diet, containing 1/3 each of saturated, monogenic and polygenic fatty acids and no more than 300 mg cholesterol daily is thought to be "safe" for the general public (Cross and Overby, 1988). Saturated fats have also been implicated in hypertension, stroke, diabetes and certain forms of cancer (Pearson and Dutson, 1990). All dietary guidelines include recommendations to reduce total fat intake, especially that of saturated fats. Generally, it is recommended that total fat should be reduced to 20-30% of total energy intake, with not more than 10% from saturated, 10 -15% from monounsaturated fatty acids (MUFA) and with polyunsaturated fatty acids (PUFA) at 3% or more (James, 1988).

2.3.1; Trends in demand for meat and meat products

The UN projects global meat consumption and production to rise as population and incomes increase in poorer nations. By 2050, they expected meat demand to be twice the 229 million tonnes the world consumed in 2000 (FEC, 2007). The overall growth in meat consumption worldwide for the last decade has been more significant in developing countries where starting incomes are generally low (Devine, 2003). According to Brown (2009), increased meat consumption followed rising affluence in parts of the world. It was indicated that meat consumption in China doubled between 1990 and 2002, but trends in the US and UK were relatively stable. Global meat consumption in the European Union (EU) is increasing slightly with a move from beef and lamb to poultry (Devine, 2003)

Oklahoma Co-operative Extension Service (2007) reported an increase in per capital consumption of chicken from 17.45kg in 1980 to 38.27 kg in 2004, which is 4.55kg more per person per year than the total increase in per capita consumption for all meats. Evans (2010) indicated that in the EU, poultry consumption has generally been steady at about 21 kg/person /year, nonetheless there was a dramatic rise in Eastern European nations due to increases in the intake. Before 1990, vast majority of animal products were consumed in rich countries. However in the last decade many developing nations have adopted what was once known as Western diet (CWFT, 2004).

According to Lawrence and Fowler (1997), the switch from accepting that fat contributes substantially to the flavour and eating quality of meat and to the satisfaction derived from the meal as a whole, to the view that almost any visible fat is verging on the immoral, has been nothing short of a revolution. The trend as it stands may not reverse significantly, although there are some divergent views. For instance, it has been claimed that meat from very lean pigs lacks succulence because it lacks intramuscular fat (Lawrence and Fowler, 1997). It was further stated that in the USA, hamburgers and streaky bacon had a special role in the 'great American breakfast', but such is the reaction against animal fat to the extent that even this traditional market may also diminish unless the product is changed. It is clear that the demand from the consumer is for lean meat and for joints which have been very attentively trimmed of fat, so that it is either hardly visible or appears as an even, very thin layer over the outside of the joint or piece. Whilst in many countries the populace is striving to increase its proportion of meat in the average diet, in others vegetarianism is being held up as a desirable nutritional objective (Lawrence and Fowler, 1997). This, of course disposes of a favourite view which used to be widely held that meat was essential for a healthy diet and was essential for a sense of well-being. For some people there are genuine religious reasons why they do not wish to eat meat.

Another report by Wolfe (1998) in a Healthy Focus Trend (HFT) study showed that 57% of respondents indicated that they will eat "more healthy food" if they tasted better and only 28% of them thought that healthy food taste good. The perception is that products labeled as 'low fat' or 'no fat' do not taste good. The survey results also indicated that product 'freshness' has become more important than less fat, convenience, price or other product considerations. Incorporating the benefits associated with eating low fat products and the idea or concept of freshness and taste into any promotional campaign should be enhanced and intensified in order to demystify consumers' perception about meat and meat products (Wolfe, 1998).

Although it is difficult to be absolute about any of these issues, it seems that the basic scientific position is that meat eaten in moderation and without too much attendant fat can make a valuable contribution to body development and function (Callow, 2009).The indiscriminate use of drugs, deliberate pollution of the environment and lack of concern about welfare are all problems which cause people to reconsider their automatic acceptance of the meat-eating habit. An informal survey of students in a faculty of a university revealed that 1/3 of students did not normally eat meat with reasons based on perceived moral grounds (Lawrence and Fowler, 1997).

2.4. MEAT PROCESSING AND CONSUMER PERCEPTION.

Meat processing involves animal slaughtered at facilities where the meat is to be sold or kept on-site for canning, cooking, curing, freezing, or making meat products (Tox Town, 2010). It also includes preparing byproducts such as lard, gelatin or tallow. Processed meat products are defined as those products in which properties of fresh meat have been modified using one or more procedures, such as grinding or chopping, addition of seasonings, alterations of colour or heat treatment (Aberle *et al.*, 2001). These modifications contribute to preservation, convenience, appearance, palatability, variety and safety giving the consumer a wide choice of meat products. Originally meat was processed to preserve it, but by virtue of the various procedures, processing leads to so many changes in texture and flavor which adds variety to the diet (FAO, 1992). 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. Processing also provides scope to mix the less desirable parts of the carcass with lean meat. It is also a means of extending meat supplies by including other food stuff such as cereal in the product. The extended shelf life of many processed meat products contributes to their appeal and allows them to be distributed and utilized in many different ways (Aberle *et al.*, 2001).

In the last two decades, the positive image of the nutritional value of red meat has been overshadowed by diverging developments in market and the meat sector itself (Scollan *et al.,* 2006). Consumers have been increasingly concerned about food-risks and personal health, particularly hygiene and quality and require detectable indications such as health certificates at the market place or veterinary stamps at the butcher stage (Zaibet *et al.,* 2007). In the minds of consumers, food safety risk also includes spoilage and residues such as hormones (Brewer *et al.,* 1994; Brewer and Prestat, 2002). This has resulted in an increase in demand for safe and healthy foods. The fat content and possibly negative effect of red meat on consumers' cholesterol levels have become one of their major health concerns (Resurreccion, 2002; Verbeke *et al,* 1999). The increased consumption of processed meat products has reflected in the consumer preference and taste for these products (Grunert, 2006).

Intrinsic cues (product physical characteristics such as colour, marbling taste etc) are known to carry more weight when consumers form meat quality expectations than do extrinsic cues (packaging, number of servings etc) and must therefore be entirely satisfied with the sensory properties of a product before other quality dimensions become relevant (Chambers and Bowers, 1993). A report by Brewer (2011) indicated that 90% of consumers indicate taste as a major factor in food selection, supported by the fact that several groups have found that daily meat consumers perceive pork to have better taste and be healthier and tender than do less frequent meat consumers.

Wolfe (1998) suggested that, in order to address the concerns and /or expectations of consumers, the health benefits associated with eating low fat products as well as the idea or concepts of freshness and taste need to be incorporated into any new promotional campaign to meet the new trend in consumer preference.

2.5 DEFINITION OF QUALITY

Quality can be defined from many viewpoints. From the consumers' angle, it may be value for money. In the Australian Standards Association's literature, it is described as "fitness for purpose". Juran (1974) defined quality as "fitness for use". According to Amerine, *et al.* (1965), quality is defined as any of the features that make something what it is or the degree of excellence or superiority. Stephens (1979), however, pointed out that quality is relative and does not necessarily mean superior or inferior or the like. According to him, it means uniformity, consistency and conformity to a standard or specification. There is no single level of quality, or is there an absolute quality level. These definitions place emphasis on the consumer aspect of quality. They encompass freedom from defects and multiple elements required to meet the total needs of the customer. This implies that quality is measured by the degree of customers' satisfaction with a product's characteristics or features. Crosby, (1979) described quality as conformance to requirements or specification. It was stated that, in order to manage quality adequately, it must be measured and compared with a standard.

Traditionally quality has been defined as meeting or satisfying customer demand, but is becoming more today and especially in the future, a measurement of how-much a product or service "exceeds" customer expectation. (House, 1991). The German Association of Quality (GAQ) defines quality as "the entirety of all properties and characteristics of a product or of an activity which refers to its suitability to fulfill given requirements (IFF, 1986). In the ASQC document, a consensus definition of quality was given as "the totality features and characteristic of a product or service that bear on its ability to satisfy given needs (ASQC, 1998).

The word quality is used in various ways as. Quality product to the salesman means one of a high quality and usually of expensive nature. For fresh produce, the word “quality” refers to the attributes of the food which makes it agreeable to the person who eats it. This involves positive factors such as colour, flavour, texture and nutritive value as well as the negative characteristic such as freedom from harmful micro-organisms and undesirable substances.

2.6 MEAT QUALITY

There are two major aspects of meat quality: nutritional quality which is objective and ‘eating quality’ as perceived by the consumer to include flavours, juiciness, tenderness and colour may be highly subjective (FAO, 1992). The nutritional quality of meat is increasingly becoming important to consumers as well. This includes the amount of vitamins, essential minerals such as iron and types of fatty acids such as Omega 3. Campbell and Jopson (2008), described the eating quality of lamb to include traits such as meat and fat colour, pH, tenderness and factors affecting the eating experience such as taste, juiciness and smell. The consumer demands that meat is tender, appealing to the eye, wholesome and safe for consumption, nutritious and affordable, (FAO, 1992).

2.6.1 Nutritional Quality of Meat

The nutritive quality attributes of meat include the nutrient content, nutrient availability and caloric value (Adegoke and Falade, 2005). Meat is high in both protein quality and quantity. According to Bastin (2007), the nine essential amino acids that the body cannot make are found in meat, thus making it a complete protein. The vitamins and other nutrients that subsist in steaks of pork and chicken include vitamins A, B and D (Callow 2009). Red meat is a good source of both vitamin B_{12} and iron and eating moderate amounts of it can reduce one’s chances of becoming anaemic (Reinmuth, 2010). Callow (2009), suggested that consumption of poultry, fish and lean cuts could be the best options to minimize some health hazards that are normally associated with meat. Goat meat has been established as a lean meat with favourable nutritional quality and it is considered an ideal choice of the health-conscious consumer (Correa, 2010). The nutrient composition of goat meat compared to the meat from other farm animals is illustrated in Table 3.

Table 3. Nutrient composition of goat and other types of meat per three 3 oz (85g) of Cooked Meat.

NUTRIENT	GOAT	CHICKEN	BEEF	PORK	LAMB
Energy (Calories)	122	162	179	180	175
Fat(g)	2.6	6.3	7.9	8.2	8.1
Saturated fat (g)	0.79	1.7	3.0	2.9	2.9
Protein (g)	23	25	25	25	24
Cholesterol (mg)	63.8	76.0	73.1	73.1	78.2
USDA [nutrient Database for Standard Reference, Release 14] (2001)					

Culled from Correa (2010)

Correa (2010) reported that goat meat is lower in calories, total fat, saturated fat and cholesterol than traditional meats and had higher levels of iron (3.2 mg) compared to a similar serving size of beef (2.9 mg), pork (2.7 mg), lamb (1.4 mg) and chicken (1.5 mg). It was also indicated that goat meat compared with others, contained higher potassium content with lower sodium levels and, closely resembled that of beef and lamb, in terms of essential amino acid composition.

2.6.2. Eating Quality of Meat

Amongst the attributes of eating quality, colour, and the odour of meat are detected both before and after cooking and provide the consumer with a more prolonged sensation than do juiciness, texture, tenderness, taste and most of the odour which are detected on mastication (Lawrie, 1991) . It was indicated that, whatever the scientific basis of these attributes may be, their significance will be determined by regional preferences and by the views of the individual consumer where some prefer markedly tough meat, others prefer excessive tenderness. Nevertheless, between the member states of the European Economic Community, less extreme opinions prevail and attempts to identify common standards of meat quality have been made in the interest of international trade.

The appearance (colour) of cooked or raw meat is important because consumers associate it with the product's freshness and they decide whether or not to buy the product based on their opinion of its attractiveness (Adegoke and Falade, 2005). Discolouration can be related to the amount of myoglobin and haemoglobin that are present in the meat, the chemical state of the pigments, or the way in which light is reflected off the meat. According to Gregory (1992), under extreme environmental temperatures or stress due to live handling immediately before slaughter can cause broiler and turkey breast meat to be discoloured. The Agricultural Marketing Service (1995) reported that about 29% of all carcasses processed in the U.S are downgraded and majority of these defects (28%) are from bruises.

At present texture and tenderness are rated as most important by the average consumer among the attributes of eating quality and appear to be sought at the expense of flavour or colour (Lawrie, 1991). After consumers buy a meat product, they relate its quality to the texture and flavour when eating. Simm *et al*. (2004)

indicated that there was increased toughness and flavour with hoggets over 9 months, and that these characteristics may accentuate following a prolonged store period or severe weaning check and/ or management techniques which are sometimes used to increase carcass weight of genetically small animals. Anything that interferes with the formation of rigor mortis or the softening process that follows it will affect meat tenderness (Adegoke and Falade, 2005). For example, birds that struggled before or during slaughter had their muscles run out of energy faster and rigor mortis forms much faster than normal. The texture of these muscles tends to be tough because energy was reduced in the muscles. They also indicated that birds exposed to environmental stress (hot or cold temperatures) before slaughter, high pre-slaughter stunning, high scalding temperature, longer scalding times and machine picking can also cause meat to be tough.

Flavour is a quality attribute that consumers use to determine the acceptability of meat. Both taste and odour contribute to flavour, and it is generally difficult to distinguish between the two and they are normally evaluated together for a reliable determination of a product flavour during consumption (Adegoke and Faladay, 2005). When meat is cooked, flavour develops from sugar and amino acids interactions, lipid and thermal oxidation and thiamin degradation, but can differ a great deal owing to meat treatment and the use of salt, spices and food additives (FAO, 1990c). Lawless (1991) indicated, that even though the age of the bird affects the flavour of the meat, slight effects on meat flavour that pass unnoticed by consumers are related to strain of bird, diet, environmental conditions (litter, ventilation, etc) scalding temperature, chilling, product packaging and storage.

2.7 RESIDUES IN MEAT AND MEAT PRODUCTS

The NRSAR, (2006-07), described residues to include pesticides and veterinary drugs currently in use, or pesticides that are no longer registered for use, but are known to persist in the environment (e.g. some organochlorine chemicals). It also includes derivatives of chemicals, conversion products, metabolites, reaction products and impurities considered to be of toxicological significance. For purposes of setting maximum residual limit (M R L), the APVMA, (2000) defined residue as the chemical, its metabolites and related compounds to which the MRL applies. The MRL is the maximum concentration of a residue that is legally permitted or recognized as acceptable in or on a food, agricultural commodity or animal feed (NRSAR, 2006-07). Toxic compounds which may be found in meat and meat products can be traced to treatment of animals with drugs for therapeutic or nutritive purposes, pollution of the environment where pollutants are transferred into the animal by way of the alimentary tract, and uptake or formation of toxic compounds during processing (Cross and Overby, 1988).

Agricultural compounds and veterinary drugs help keep animals and crops free from pests and diseases, but one consequence of this is that some traces of the chemical may remain in meat, fruits or vegetables at the time they are slaughtered or harvested (NZFSA, 2007). Sedation of animals prior to and during transport may decrease the risk of intraspecific aggression in assembled and transported boars, but may not be a viable option due to residue problems and overall lack of effectiveness in some of them such as stresnil in pigs, which can persist in the human body so that repeated intakes would possibly result in accumulation of the drugs (Trevor *et al*., 2010). Subramanyan, (2009) indicated, that animal feed can be contaminated with industrial pollutants, heavy metals, radionuclides, toxins from microorganisms, toxic substances from plants particularly fodder plants and residues of pesticides accumulated by the plants during their growth from chemicals persistent in the soil. It was also indicated that chemicals used to manage pests during crop production in the field and during storage of the harvested commodity are also sources of contamination of livestock feed and are likely to be deposited on fat and muscle tissue. Kan and Meijer (2007) indicated that feedstuffs may also contain veterinary drugs and certain contaminants, which besides impacting negatively on quantity and safety of feed, also tend to accumulate in the animal tissues and products which would subsequently impact human health.

However, Cross and Overby, (1988) mentioned that contamination of muscle tissues by lead and cadmium are only slightly affected by the level of these elements in animal feed, as the animal organism exerts a “filter” effect which makes it possible to transform a highly contaminated food (plant) into a slightly contaminated food (meat) by feeding. Nonetheless, high levels of lead and cadmium in the feed resulted in elevated residues in liver and kidney. D`Mello (2004), reported that dioxin-contaminated animal fat that was accidently added to animal feed revealed that meat products and eggs from animals fed those feeds contained high levels of dioxin. The MAFF (1994) indicated that the Chernobyl accident in 1986 led to contamination of pasture with Cesium 134 and Cesium -137 radionuclides which contaminated milk and sheep carcasses. Voegborloh *et al*. (2007) reported that vegetation and soils along major highways were polluted by heavy metals from exhaust fumes and tyre wear. This suggests that food vendoring and animals grazing along highways with heavy traffic could result in contamination with heavy metals.

A report by Okiel *et al*. (2009) indicated significantly high level of Cr, Hg, and As, except Cd and Zn in processed cattle hides ‘ponmo’ prepared by known and unknown processing methods after boiling. It was indicated that cattle hides processed by burning with firewood, plastics, and tyres contained toxic levels of Pb, Cr, Hg and As thereby causing environmental pollution because of the toxic compounds released to the atmosphere. Thus, cattle hide processors are therefore highly at risk as they handle ash containing toxic metals and inhale vapours of compounds emitted during the combustion of these fuels.

The increased use of antibiotics has given rise to fear of the development of resistant bacteria which directly or via the meat could be transferred from animals to humans (Jensen, 2010). Human health can either be affected directly through residues of antibiotics in meat, which may cause side-effects, or indirectly, through the selection of resistance determinants that may spread to pathogens that infect humans (Hughes and Heritage, 2004). Grassner and Wuethrich, (1994) demonstrated the presence of chloramphenicol metabolites in meat products and concluded that a link with the presence of these antibiotic residues in meat and the occurrence of aplastic anemia could not be ruled out. An outbreak of food poisoning caused by a resistant strain of salmonella was linked to hamburgers made from cattle fed with chlortetracycline (Bonner, 1998). Spika *et al.* (1987) traced a chloramphenicol resistant strain of *Salmonella enteric var Newport* from beef burgers to herds that had been dosed with chloramphenicol. Jensen (2010) concluded that all these could lead to reduction in options for using valuable antibiotics to fight diseases in both animals and humans.

Generally, growth promoters are compounds that are added to feeds to improve feed utilization and the growth of farm animals. All non-nutrient feed additives such as antibiotics and chemotherapeutics that improve animal growth can in principle be described as growth promoters (Jensen, 2010). In the US, approximately 36 million cattle are raised annually to provide beef for consumers and two-thirds of these cattle (about 24 million) are given hormones to help make them grow faster (Raloff, 2002). Steroid hormones which enhance the animal's muscle production are administered through the feed or by way of hormonal implant on their ears. The European Union's Scientific Committee on Veterinary Measures Relating to Public Health (SCVPH) (1999), indicated, that the use of six natural and artificial growth hormones in beef production poses a potential risk to human health. Although the United States Department of Agriculture and Food and Drug Administration claimed these hormones are safe there is growing concern that hormone residue in meat and milk might be harmful to human health and the environment. It was further stated that, when natural hormones are fed to cattle the level of their hormones increase from 7 to 20 times more, which questioned the possible side effects on the human body after consuming these hormones in meat and dairy products. After a thorough research, the SCVPH concluded that "no acceptable daily intake could be established for any of these hormones" and those who consume food products with hormonal residues are at a great risk of severe hormonal imbalance as well as various types of cancer. The Globe and Mail (1999) stated that, residues of hormones in beef have also been implicated in the early onset of puberty in girls, which could put them at a greater risk of developing breast and other forms of cancer.

Barrett (2010) reported that both the Food and Drug administration (FDA) and a joint committee of the Food and Agricultural Organization and World Health Organization (FAO/WHO) deemed that the residues of six steroid hormones that are currently approved for use in US livestock were safe for human consumption. It was indicated that more than 90% US livestock are currently injected with these hormones, which increased veal and beef by up to 15%. The hormonal treatment increased animal's growth by 20%, so that each animal in a feed-lot typically gained 3 pounds (about

1.36 kg) per day. This was evident by the fact that for each pound that a cow gains it consumed 15% less feed than an untreated animal did which worked out to a cost savings of about US$40 per head.

The Canadian Health Coalition (2001) stated that, reports from the expert scientist appointed by the E U on the use of growth hormones in food animals poses a potential risk to consumers health because hormone residues found in meat from these animals can disrupt the hormonal balance of consumers causing developmental problems, interference with the reproductive system and even lead to the development of cancer.

The use of antibiotics for growth promotion has risen with the intensification of livestock farming and the control of infectious agents which reduce the yield of farmed food animals. Hughes and Heritage (2004) stated that sub-therapeutic dose of antibiotics and other antimicrobial agents have proven effective in their control. The term antibiotic growth promoter as used by these authors is any chemical that destroys or inhibits bacteria and is administered at low, sub-therapeutic dose.

According to the NOAH, (2001), antibiotic growth promoters (AGPs) are used to “help growing animals digest their food more efficiently, get maximum benefits from it and allow them to develop into strong and healthy individuals”. Jensen (2010) reported that when antibiotic growth promoters were added to feed, there was an improvement in the digestibility and uptake of feed along the alimentary canal, and reduced the opportunity for harmful bacteria. At low doses in animal feeds, AGPs were considered to improve the carcass quality, with a low percentage of fat and high protein content in meat. Other benefits of the use of AGPs included control of zoonotic pathogens such as *Salmonella*, *Campylobacter*, *E coli* and *enterococci* (Hughes and Heritage, 2004)

2.8 HIDE

Hide to the living animal is to accomplish several essential functions, including protecting the body from injuries, climatic and environmental influences, and body temperature regulation (LANXESS, 2010). It was also stated that the raw hides/skins are provided as by-product of the meat industry for leather production of which majority are made from farm animals. However, the types of leather produced in a particular area are often a matter of tradition and linked to the available hides and skins of domestic animals from this region

Basically, the skin of animals is made up of collagen. Lawrie (1991) stated that collagen is composed of three polypeptide chains that are wound together into an X-helix-like three strands twisted together and held by hydrogen bonding. It was further indicated that, as the animal ages, the cross-links in the collagen chains increase and this makes it tougher. The ACS in 2003 stated that gelatin is basically processed collagen which is a structural protein in animal's connective tissue, skin and bones.

2.8.1 Value of Hides

The tanning industry and the downstream industries such as footwear, furniture automotive, clothing, leather goods, and saddler are entirely dependent for their raw material on suppliers of cattle hides, sheep skin and small number of goat and other skins (ICT, 2010). Pork skin, cattle bones and hides are the predominant raw materials for gelatin production. Gelatin is used primarily in the food, pharmaceutical and photographic industries and is consumed in gelatin desserts and confection such as ice cream, sour cream, meat aspics and cake frostings (ACS, 2003).The GMIA, (2001) also reported a brand-new application for gelatin in the paint ball industry.

Hides, through the tanning process, have been made into useful leather products and the collagen in them is mainly used to make sausage casings. The United States is the world's largest producer and leading exporter of hides and skins. According to Elias and Ralph (1996), the total US production of raw cattle hides and skin in 1996 was forecast to rise about 3% to 1.19 million metric tons of which 54% was for export. They also reported that in 1995 the total US exports of cattle hides and skins were valued at $1.44 billion up 14% from 1994. A report by Mwinyihiya (2008) indicated that in Kenya, the hides, skins and leather industry contributed an estimated 4.5 % to agricultural gross domestic product (GDP).It was also reported that in the recent past in Kenya, an economic survey showed a 10.3% growth in the leather sector. On the other hand, Ghana does not export any hides or leather, even though it has the potential of increasing the production of cattle hides and sheep and goat skin with off-take rates of 11% for cattle and 30% for sheep and goats (Veterinary Services Directorate, 2005). However, a total of 2,426 pieces of leather goods valued at US$ 3,954 were exported in 2005 from Ghana to the outside world (Ministry of Trade and Presidential Special Initiative, 2005). It is believed that the recorded value was underestimated as those taken out of the country by tourists as well as Ghanaians travelling abroad were unrecorded. In 2003 the value of percussion musical instrument, a traditional drum exported from Ghana was valued at US$958,000 (GEPC, 2005).

In spite of the economic potential of hides/skins as raw material for leather production, the major use of skin in Ghana is for human consumption. Hide/skins are processed into 'welle', a delicacy consumed by all social classes (Oppong-Anane and Apori, 2007). Lawrie (1991) stated that meat with high percentage collagen or elastin would have relatively lower intrinsic biological value. However, Kofranyi and Jekat

(1969) demonstrated that for human consumption, connective tissue might not be nutritionally disadvantageous, unless the ratio of connective tissue to muscle tissue nitrogen is more than one.

Hides and skin play a very important socio-cultural role among the people of Northern Ghana. Animals skin, mostly cattle skin, serves as the official seat of the chiefs in the three Northern Regions of Ghana. They are also used for clothing and sometimes as mats and other handicrafts (Oppong-Anane and Apori, 2007).

2.8.2 Chemical Composition of Cattle Hide

The bovine hide is basically made up of collagen which is essentially protein. Moore and Stein, (1951) reported that the amino acid composition of the citrate-soluble collagen of calf skin is 97.3%N compared to 96.97%N of an adult ox hide collagen. This indicates that both calf and adult skins are essentially similar, though there are some differences in terms of percentage nitrogen. The crude protein (CP), ether extract (EE) and ash values reported by Ofori (2001) for bovine hide ranged from 56.46 - 69.19%, 1.04 - 3.58%, and 1.33 - 1.94% respectively. Agbovi (2001) also reported similar results. According to Estoe and Long (1960), collagen is deficient in most indispensable amino acids and also poorly digested owing to its poor amino acid balance.

To a large extent, the type of material used in processing (singeing) meat animals affects their chemical composition (Lawrie, 1991). This fact was supported by Ofori (2001) who indicated that different singeing materials significantly affected the crude protein, fat and ash levels. The chemical composition of meat and hides could be contaminated with various minerals and organic compounds from the environment in the live animal (Cross and Overby, 1988) and during processing using various materials as sources of fuel for singeing slaughtered animals and hides (Obiri-Dasno *et al.*, 2008; Okiel *et al*., 2009).

2.9 SMOKE

Wood smoke is a complex mixture of substances produced during the burning of wood. It contains many organic compounds known to cause cancer. These include benzopyrenes, dibenzanthracenes, dibenzocarbazoles and other toxic compounds such as aldehydes, phenols, or cresols (Ammann, 1986). Wood smoke compounds are also known to have fungistatic effect, and therefore prevent growth of moulds and yeasts (FAO, 1990). Generally, smoke produced by the slow combustion of wood (consisting of about 40 - 60% cellulose, 20 - 30% hemicelluloses, and 20 - 30% lignin) inhibits microbial growth and activity, retards fat oxidation and imparts flavor to meat (Callow, 1932). It was stated that smoking influences the taste, appearance and shelf-life of treated products. Certain constituents of wood smoke, such as formaldehydes and creosote-like volatile compounds, also affect the surface texture of the products by tanning or coagulation of the muscle fibres of meat or natural casing (Girard, 1992). Cross and Overby (1988) indicated that during smoking, drying the product surface to optimize smoke absorption enables the Millard browning reaction to proceed at a reasonable rate and lowers the moisture contents of the product sufficiently to inhibit microbial growth.

Traditionally, smoking is consists of burning the wood beneath the meat in open air. Wood is an excellent fuel since 99% of it is combustible (Ranjhan, 1997). Also, woods vary greatly in their energy value which relates to the density and amount of moisture. According to Lawrie (1991), the average caloric values of seasoned wood is reported to be around 4600 calories/kg, 2 kg of which yield approximately the same heating value as produced by 1 kg of good coal. Thus, the process of meat smoking can be more speedily carried out, and a product of consistent quality produced by controlled smoking in a kiln and by electrostatic deposition of wood smoke particles.

Even though the use of scrap tyres and LPG in meat smoking is not traditionally known, they can be effective in inhibiting microbial growth, act as a preservative and increase the shelf life of the product. Liu (1993) indicated that when scrap tyres undergo pyrolytic process, they yield gaseous, liquid and solid compounds. It was further stated that the gaseous compounds contain more than 50% hydrogen with 900 Btu/ft^3 heating value, liquid compounds which include about 15% olefins by volume, 50% aromatics and 35% paraffins and cycloparaffins combined, whilst the remaining solid residue is a mixture of carbon, sulfur and ash with a heating value of approximately 13000 Btu/1b. As much as smoking confers some desirable qualities on the product, it can also have certain detrimental effects on products, processors and the environment at large. The product could be contaminated with certain toxic constituents of the smoke particularly 3, 4-benzoprene. The process could also degrade essential amino acids of proteins and also presumably vitamins. It is estimated that wood smoke is 12 times more carcinogenic than equal amounts of tobacco smoke and attacks our body cells up to 40 times more than tobacco smoke , so inhaling wood smoke particulate matter increases the incidence, duration and severity of respiratory diseases, especially in children, the elderly and those with lung and heart disorders (CAR, 2007).

Burning scrap tyre in cement kiln revealed that benzene, heavy metals and dioxin are released and these are associated with a wide range of serious health problems including reproductive impairment, developmental delay and cancer (Anonymous, 2006). It was reported that burning tyres also presents the potential for loss of productivity and reduced marketability of agricultural products in areas impacted by waste burning facilities

2.10 COMPOSITION OF RUBBER TYRE

Approximately 80% of the weight of car tyres and 75% of truck tyres is a rubber compound usually reinforced with steel, textile, rayon nylon, fibreglass and polyester (Base Convention Work Group, 1999; Cook and Kemm, 2004). A wide range of chemical compounds, such as natural rubber, styrene butadiene rubber (SBR), and butadiene rubber can be found in the tyre rubber of road vehicles. The California Integrated Waste Management Board (1992) indicated that tyres were composed of natural rubber from rubber trees, synthetic rubber made from petrochemical feedstocks, carbon black, extender oils, steel wire, other petrochemicals and chlorine and up to 17 heavy metals. Chemical analysis revealed that metals such as Zn, Fe 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). Typical constituents of tyres are shown in Table 4.

Table 4: Typical Constituents of Tyre

Rubber	51%
Carbon black	26%
Oils (paraffin and aromatic)	13%
Zinc Oxide	2%
Sulphur (vulcanizer)	1.0-1.5%
Halogens	0.5%
Others	7%

Source; Cook and Kemm (2004)

2.10.1. Trace Metals and Dioxins

2.10.1.1 Trace Metals

These are essential metallic elements necessary to maintain the metabolism of the human body, but could be poisonous, at higher concentrations (Lentech Water Treatment and Purification Holding (LWTPH), 2009). They occur naturally in earth's crust and are present in all ecosystems in varying concentrations. Heavy or toxic metals are trace metals with a density of at least five times that of water and cannot be degraded or destroyed and therefore bioaccumulate (Farr, 2004).

Iron and zinc, for example, prevent anemia and are constituents of over 200 and 300 enzymatic reactions in body functions, respectively (Eurometaux, 2010). High levels of copper, an essential substance, can also result in zinc deficiency which causes anemia, liver and kidney damage, stomach and intestinal irritation (Kilic, 2011).

Heavy metals can also increase the acidity of the blood. The body draws Ca ions from the bones to help restore the proper pH (Farr, 2004). It was further reported that toxic metals set up conditions that lead to inflammation of the arteries where the calcium hardens the arterial wall and causes a progressive blockage of the arteries. It was also stated that without the replenishment of calcium, the constant removal of this important mineral from the bones will result in osteoporosis especially in children and the elderly due to either under-developed or age-compromised immune systems.

2.10.1.2 Dioxins

The term "dioxin" refers to a group of persistent, very toxic chemicals including dioxins, furans and some polychlorinated biphenyls (PCBs) which share certain chemical structures and biological characteristics (Cook and Kemm, 2004). In environmental work, the term dioxin is usually applied to polychlorinated dibenzoparadioxin (PCDDs) and it is the nastiest most toxic man-made organic chemical with toxicity second only to radioactive waste (QFAC, 2010). Cook and Kemm (2000) indicated that more than 440 types of dioxin-like compounds exist, but only 30 are considered toxic. The most toxic of this group is 2,3,7,8 tetrachlorodebenzo-paradioxin (2, 3, 7, 8 TC DD). Dioxins have no use and are by products of human activities such as waste incineration, fuel combustion, and chlorine bleaching of pulp and paper or pesticide manufacturing (QFAC, 2010).

Environmental protection agency data ranks municipal waste incineration, hazardous waste burning, cement kilns and medical waste incinerations as the leading source of dioxins (Cook and Kemm, 2004). Furthermore, dioxin have the tendency to accumulate in fatty tissues of animals consuming those plants and concentrate in meats, eggs and dairy products and consequently in humans. A study of biomagnifications of low levels of dioxin from soil and feed into chickens showed levels of dioxin found in eggs and chicken tissues to be 10 to 200 fold higher than the soil concentrations (Anonymous, 2006).

Dioxins are biologically active and in animal models are carcinogenic, tetratogenic, damage liver, skin and the immune system and are endocrine disruptors (Cook and Kemm, 2004). Exposure to dioxin has been linked to birth defects, inability to maintain pregnancy, decreased fertility, reduced sperm counts, endometriosis, diabetes, learning disabilities, immune system suppression, lung problems, skin disorders, lowered testosterone levels, chronic fatigue syndrome and other nerve and blood disorders (QFAC, 2010). It was further stated that there is no “threshold” dose for dioxin (i.e. the tiniest amount can cause damage and our bodies have no defense against it).

2.11 EXPOSURE PATHWAYS OF HEAVY METALS AND THEIR EFFECTS ON HUMAN HEALTH

Once liberated into the environment, heavy metals are taken into the body via inhalation, ingestion, and skin absorption where they gradually build up and accumulate faster than the body's detoxification pathways can dispose of them. In addition to the hazards at home and outdoors, many occupations involve daily heavy metal exposure, of which Hg alone has been implicated in over 50 professions (Farr, 2004).

Heavy metal pollution is a problem mostly associated with areas of intensive industry. However, 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 of the total metals in road runoff. Other sources of accumulation of these metals in the body are through the eating of contaminated fish, chicken, eggs and other food sources (ACS, 1997). Scrap tyres which contain these metals may partly impact this on 'welle' as well as the processor as the fumes are inhaled during the singeing process.

According to Farr (2004) heavy metal toxicity studies confirm that heavy metals can directly influence behaviour by impairing metal and neurological function, influencing neurotransmitter production and utilization and altering numerous metabolic body processes. Fairfax County (2008) indicated that the effects of pH are more pronounced in the Washington DC metropolitan area due to acid rain which can cause a large increase in acidity and a corresponding increase in amounts of heavy metal becoming soluble. Appiah-Num (2004) stated that if large doses of Zn (10-15 times than RDA) are taken by mouth, stomach cramps, nausea and vomiting may occur even for a short time, while larger doses for several months could result in anaemia, damage of the pancreas and decreased levels of high density lipoprotein (HDL) cholesterol. Toxicological Profile for Manganese (TPM), (1992) indicated that very high levels of manganese in foods or water might cause brain injury. Cadmium is a highly toxic element which is both cyto-and embryo-toxic and has an extremely long biological half-life. High doses lead to severe irritation of the gut which leads to vomiting, and diarrhea (ATSDR, 1988).

2.12 TOXIC AND LETHAL DAILY INTAKE VALUES OF SOME HEAVY METALS

In 2001, the Institute of Medicine set tolerable upper intake levels of Fe as 40 mg/day for infants and children of age 13 years, 45 mg/day for adolescent ages (14-18 years) and adults of 19 years and above. The recommended daily intake (RDI) for zinc is 15 mg and doses higher than 25mg may cause anaemia and copper deficiency (LWTPH, 2010). The World Health Organization (WHO) also established a potential tolerable weekly intake (PTWI) value for Pb in adults as 3.0 mg (430 µg/day) (Appiah-Num, 2004). Lethal daily intake values for Cd, Pb, Mn, Zn, and Fe are shown in Table 5.

Table 5: Toxic and lethal daily intake values for Cd, Pb, Mn, and Fe

Metal	Toxic intake	Lethal intake
Cd	3-330mg	1.5-9g
Pb	1mg	10g
Mn	10-20mg	None
Zn	150-600mg	6g
Fe	>0.5g	7-35g

Source; Mensah (2002)

2.13 INFERENCE FROM THE LITERATURE REVIEW

Meat is a very good source of essential amino acids, vitamins, minerals and essential fatty acids. Hence, human diets should contain at least some meat and or meat products in order to guarantee proper nutrition as most plant sources cannot solely provide all the essential nutrients necessary for normal development and growth.

Variety meats are by-products of non-skeletal muscle origin which include edible organs such as liver, skin, bone marrow, kidneys and lungs. Sausages that contain variety meats have an equivalent and most often a superior nutritional value to those containing only skeletal muscle meats.

Raw hides and skins are provided as by-products of the meat industry. They have many industrial uses and also serve as source of protein in many developing countries including those in sub-Saharan Africa. Hides and skins may contain various chemical components that qualify them as sources of protein and other nutrients. However, the implication of collagen as the predominant component puts many in doubt as to whether it is of any nutritional value.

Lawrie (1991), reported on the significance of including connective tissue as protein source in diets for human consumption, however, little evidence has been documented regarding its chemical composition and quality as food. Another area of much concern is the nutritional safety of the hides/skins, since several materials are being used in the singeing process.

This study was therefore designed to assess the nutrient composition and the level of heavy metals in hides/skins processed for human consumption.

CHAPTER THREE

MATERIALS AND METHODS

3.1 SAMPLING AREA

The sampling was done in Buipe, the district capital of the Central Gonja District of the Northern Region. The Buipe District shares boundaries with the following districts; Tamale to the north, Kintampo to the south, Salaga to the east and Damango to the west. It is located between the two Volta Rivers (white and black). The inhabitants are basically fishermen, and crops and livestock farmers. There is a slaughter slab where animals are slaughtered for meat. The slaughter rate is 0-3 for cattle and 5-12 for small ruminants per day.

3.2 RAW MATERIALS

A total of thirty (30) fresh cattle hides were acquired over a period of one month and preserved in a deep freezer at a temperature of -18^{0}C. Four (4) pieces of 6 cm^2 were randomly cut from each hide. In all, a total of 120 pieces of hide were obtained and used for the study.

3.3 TREATMENTS

3.3.1 Treatment for Metal Contents in 'Welle'

Thirty (30) pieces of fresh hide were randomly selected and allocated to four processing treatments including fermentation (F) which served as the control, firewood (W), Tyre (T) and LPG (G). The treatments were further subtreated as unwashed (u), washed (w) and boiled (b) and designated as F(u,w,b), W(u,w,b), T(u,w,b), G(u,w,b). Copious amount of water was used to wash the 'welle' and boiled. An amount of 2 litres of water was used to boil 0.25kg of 'welle' at a temperature of 100^o C for 4 hours. Each sub-treatment contained 10 replicates which were composited into three (3) replicates thus making a total of 36 treatments (Table 1. in Appendix). The quality control and reference standards analysis are indicated in Table. 2 in the appendix. The various treatments and sub-treatments considered are indicated in Table 6.

Table 6: Treatments for metal contents in 'welle'.

Treatment	Sub-treatment		
Fermentation(F)	Fu	Fw	Fwb
Wood (W)	Wu	Ww	Wwb
Tyre (T)	Tu	Tw	Twb
Gas (G)	Gu	Gw	Gwb

u, w, and wb are unwashed, washed and, washed and boiled sub-treatments of Fermentation, Wood, Tyre and Gas respectively.

3.3.2 Treatments for Nutritional Composition of 'Welle'

In order to assess the nutritient composition of 'welle' three (3) washed samples each were taken from the four treatments and analyzed in triplicates using standard procedures of the Association of Official Analytical Chemists (AOAC) (1990). Thus, the treatments obtained are shown in Table 7.

Table 7: Treatments for nutrient composition of 'welle'.

Treatments	Replicates			Means
Fermentation	Fw_1	Fw_2	Fw_3	Fw
Wood	Ww_1	Ww_2	Ww_3	Ww
Tyre	Tw_1	Tw_2	Tw_3	Tw
Gas	Gw_1	Gw_2	Gw_3	Gw

3.4 CHEMICAL ANALYSIS

3.4.1 Metal Analysis

Each treatment was analyzed in triplicate for Fe, Mn, Zn, Cu, Pb and Cd at the Chemistry Laboratory of the Ghana Atomic Energy Commission (GAEC), Accra.

3.4.1.1 Materials, methods and Equipment Used

- Milled samples of the various treatments: i.e F(u,w,b), W(u,w,b), T(u,w,b) and G(u,w,b) were digested using Milestone microwave labastation (ETHOS 900)
- 0.5 gm of milled cattle hide from the various processing treatments were measured into labeled 100 ml polytetraflouroethylene (PTFE) Teflon bombs.
- 5.0 ml of concentrated HNO_3 (67%) and 1.0 ml of H_2O_2 (30%) was added to the samples in the Teflon bombs.
- The samples were then loaded onto a microwave carousel (roto) and the Teflon bombs were secured with vessel caps using an approximate screw tool.
- The complete assembly was microwave- irradiated in a Milestone microwave Labstation (ETHOS 900) using the following operational parameters; total power 1550W, total pressure 900 Bm, total time 22 min and total temperature of 900^0C.
- After 22 min, the Teflon bombs still mounted on the roto were removed from the ethos 900 and cooled in running tap water in a bath to reduce internal pressure and to allow volatilized material to resolubilize.
- The digestate was topped up to 20 ml with doubly distilled water and assayed for the presence of metals on a Varian A A240 Atomic Absorption Spectrophotometer in acetylene-air.

3.4.2 Analysis of Nutrient Composition of 'Welle'.

Proximate analysis of the variously treated cattle hides were carried out at the Nutrition Laboratory of the Department of Animal Science, KNUST to determine the Crude Protein (CP), Ether Extract (EE) and ash contents. The standard procedures used were those of the Association of Analytical Chemists (AOAC, 1990).

3.5. STATISTICAL ANALYSIS

The experimental design used in the assessment of metal contamination of the cattle hides was a 4 X 3 factorial in Complete Randomized Design (CRD). The mean values of the data obtained for the metal concentrations were subjected to "Two-way Analysis of Variance (ANOVA) technique using GenStat Discovery Edition 3, (2008) software. Significant differences ($p < 0.05$) between mean values were separated by the least significant difference (Lsd) test.

The experimental design for the chemical composition of the various treatments was the Complete Randomized Design (CRD). The values obtained were also subjected to a One-way ANOVA, using GenStat Discovery Edition 3, (2008) software and where significant differences existed ($p<0.05$) mean values were separated by the least significant difference (Lsd) test.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 METAL CONTENTS IN 'WELLE'

The effects of the different processing methods on the metal content in cattle hides are presented in Table 8. Analysis of cattle hides revealed sub-lethal levels of all the metals under investigation, except Cu which slightly exceeded its maximum permissible level (MPL) in only the fermented, washed and boiled (Fwb) treatments. In all the processing methods used, 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 (USDA, 2006; OJEC, 2001).

Table 8: Effects of Different Processing Methods on Metals Content in 'Welle' (mg/kg)

Metal Contents	Treatments				LSD	CV (%)
	Fermentation	LPG(G)	Tyre	Wood		
Fe	210.11^{a}	127.00^{c}	117.67^{d}	148.11^{b}	0.08	0.1
Mn	27.86^{a}	8.58^{c}	7.77^{d}	9.17^{b}	0.06	0.50
Cu	9.66^{a}	4.91^{b}	1.13^{d}	3.16^{c}	0.06	1.40
Zn	26.60^{a}	9.77^{b}	5.73^{c}	5.65^{d}	0.07	0.6
Pb	ND	ND	ND	ND	_	_
Cd	ND	ND	ND	ND	_	_

ND = Not Detectable

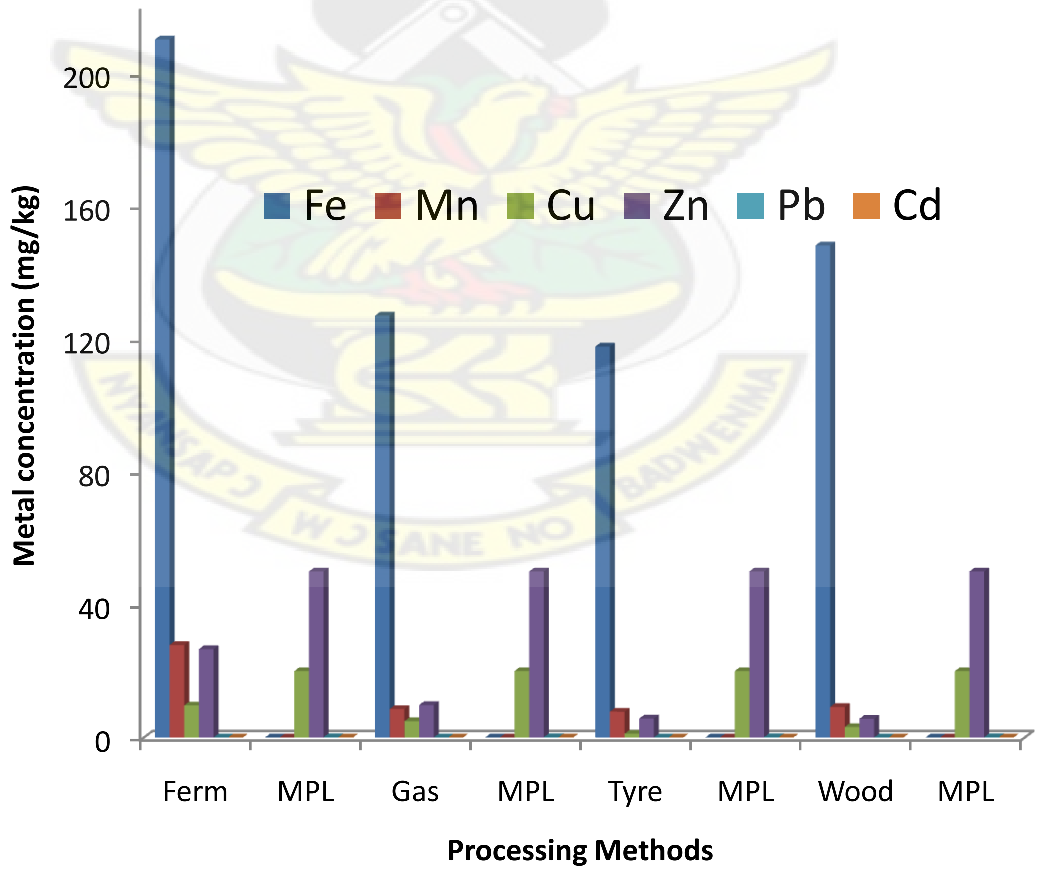
Means with different superscripts (a b c d) in the same row are significantly different at 5%

C V = Coefficient of Variation.

LSD = Least Significant Difference.

With respect to Fe, Mn, Cu and Zn, the hides which were fermented recorded the highest values of 210.11 mg/kg, 27.86 mg/kg, 9.66 mg/kg and 26.60 mg/kg, respectively. The tyre treated samples recorded the lowest concentration values of 117.67 mg/kg for Fe, 7.77 mg/kg for Mn and 1.13 mg/kg for Cu. In the case of Zn wood treated hides registered the lowest concentration value of (5.65 mg/kg). The treatment means for all the metals showed significant difference ($P<0.05$). Comparing these values to MPLs, Cu, Zn, Cd and Pb are below the maximum permissible levels (MPL) except for Fe and Mn where no MPLs have been fixed for them in meat (Fig.1).

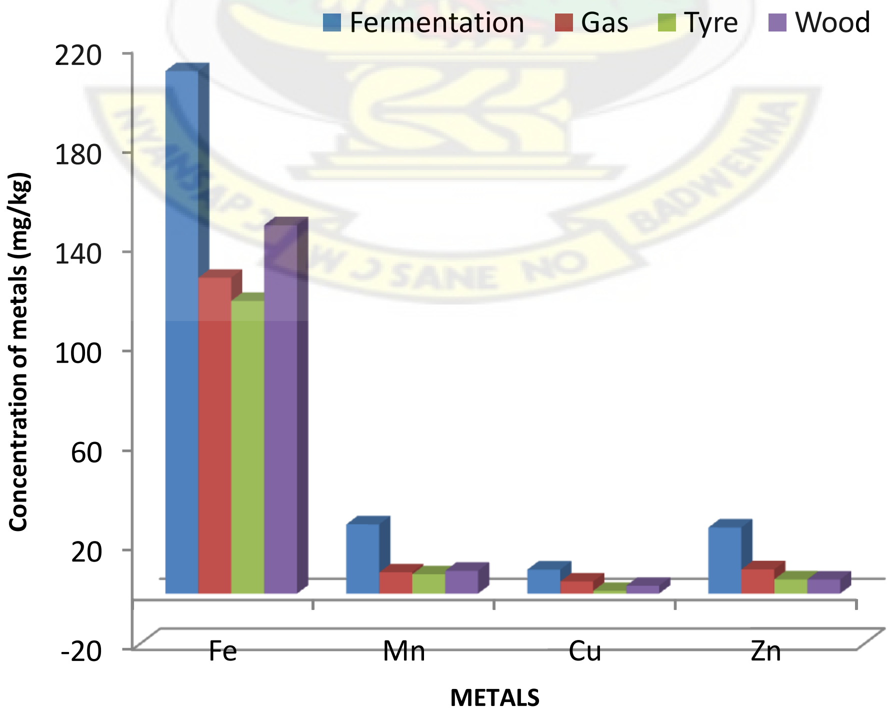
Figure 1; Effects of dehairing methods on metals concentration compared with MPL in meat



The MPL of Zn and Cu are 50 mg/kg and 20 mg/kg respectively (USDA, 2006; OJEC, 2001; ECR, 2006). However, it is unclear with regards to Mn, whether the recorded value in the hides in this study may constitute significant problem for consumers because, as a pollutant or and a contaminant, no MPL have been fixed for it in meat (MFPO, 1973). The upper tolerable intake of Mn for humans is 2-11 mg/day. In this study, the concentration of Mn ranged from 7.77 to 27.86 mg/kg. 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 'welle' consuming public.

Comparing the control samples (fermented) to the singed treatments, there is generally a decrease in metal levels as illustrated in Figure 2.

Figure 2: Comparison of metal concentrations with respect to the various dehairing methods.



Okiel *et al*. (2009) reported that the scrapings (ash) of the burnt hides contain substantial amount of these metals and may be the cause of the reduced levels in singed products. In this study, the levels of heavy metals reported in all the processed hides were generally quite low when compared to some reported cases of heavy metals concentrations in treated hide or "welle" and other meat products (Okiel *et al*., 2009; Obiri-Danso *et al*., 2008; Santhi *et al.*, 2008). The non detectable levels of Pb and Cd and moderate levels of the other metals in all processed hides (fermented and singed) could be due to the fact that animals used for this study 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. The animals are less at risk of picking heavy metals from the environment given the challenges of free-range grazing, scavenging in open waste dumps for fodder, drinking water from polluted drains and streams and exposure to automobile fumes and open burning of solid waste as pertain in the urban and peri-urban centres (Obiri-Danso *et al.,* 2008; Voegboloh *et al*., 2007; Okiel *et al.*, 2009). It has also been established that there is a close relationship between heavy metal concentration in cattle tissue with that in the soil, feed and drinking water (Qui *et al*., 2008, Voegboloh *et al*., 2007). Thus, these results to some extent, support some previous assertions that partially, attributed heavy metals in cattle hide (welle) to other environmental conditions (Obiri-Danso *et al*., 2008; Okiel, *et al.,* 2009). The values reported in this study were lower than those reported by Obiri-Danso *et al*. (2008) and Esumang *et al*. (2007) probably due to differences in the metal contents in the tyres used. Motor tyres used in this study contain less metal stripes compared to the lorry tyres as indicated by Obiri-Danso, *et al*. (2008) and Esumang *et al*. (2007).

Washing and boiling are critical and inevitable stages in processing hides (welle) for human consumption. The interactive effects of dehairing methods, washing and boiling on metal contents in 'welle' are presented in Table 9.

Generally, all the fermented, washed and boiled treatments recorded significantly ($p<0.005$) high metal contents compared to the singed, washed and boiled treatments. This suggests that the singeing process introduced some reduction effect on the metal contents in the singed products. Similar findings were reported by Obiri-Danso *et al.* (2008). The relatively low levels of metals in singed hides could be attributed to the fact, that the char or ash which may contain substantial amounts of these metals was scraped off the singed hides. Okiel *et al.* (2009) reported similar findings in a study to compare the essential metal levels of traditionally-produced 'ponmo' or 'welle' in Southern Nigeria.

The level of Fe in all the 'welle' was in the range of 73.13 mg/kg to 264.41 mg/kg of 'welle'. The average lethal dose of Fe is reported to be in the range of 200 to 250 mg/kg. According to Stancheva *et al.* (2010), the National Research Council and the US National Academy of Science recommends a daily dietary allowance of 10mg/kg for Fe in elderly women and men. However, some international standards (WHO, FDA) including the Bulgarian standards stated, that there is no information about the MPL of Fe concentration in animal source foods including fish (Stancheva *et al.*, 2010; Kamaruzzaman *et al.*, 2010). Iron concentrations in kidney, liver, beef and eggs are generally 30-150 mg/kg (wet weight basis) (Friberg *et al.*, 1979). The maximum acceptable body burden (MABB) of Fe is said to be 800 ug/kg body weight per day (Faribal *et al.*, 2009).

Table 9: Effects of Dehairing, Washing and Boiling on Metal Contents in 'Welle'

Metal contents (mg/kg)	Processing Methods												LSD	CV (%)
	Fu	Fw	Fwb	Gu	Gw	Gwb	Tu	Tw	Twb	Wu	Ww	Wwb		
Fe	196.32^{c}	169.59^{f}	264.41^{a}	75.76^{k}	146.05^{h}	159.20^{g}	92.12^{i}	180.77^{d}	80.11^{j}	170.89^{e}	200.31^{b}	73.13^{l}	0.13	0.10
Mn	40.04^{a}	22.60^{b}	20.95^{c}	6.51^{j}	8.75^{h}	10.48^{e}	7.39^{i}	10.09^{g}	5.84^{l}	11.84^{d}	10.24^{f}	5.87^{k}	0.11	0.50
Cu	4.33^{e}	4.35^{d}	20.31^{a}	8.68^{c}	3.20^{f}	2.85^{g}	0.32^{k}	1.19^{j}	1.88^{h}	0.51^{i}	0.19^{l}	8.79^{b}	0.11	1.4
Zn	22.83^{b}	21.67^{c}	35.31^{a}	8.81^{g}	10.47^{e}	10.03^{f}	7.30^{h}	4.37^{j}	5.53^{i}	3.29^{k}	4.37^{j}	10.69^{d}	0.11	0.6
Pb	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	_	_
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	_	_

ND = Not Detected

Means with different superscripts (a b c d e f g h I j k l) in the same row are significantly different at 5%

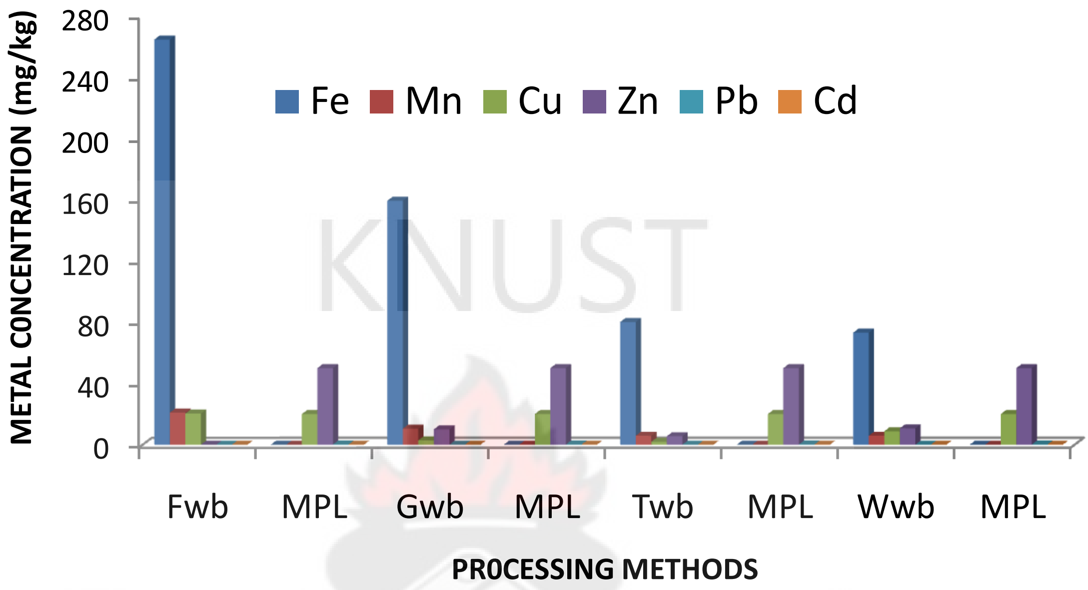
C V= Coefficient of Variation.

L S D = Least Significant Difference.

Manganese contents in all treatments ranged between 5.84 and 40.04 mg/kg (Table 9). With the fermented, unwashed (F,u) sub-treatments recording the highest value, whilst the tyre -singed, washed and boiled sub-treatments (T,w,b) recorded the lowest value. There were significant differences (P<0.05) among all treatment means. It is unclear whether the recorded values in the hides may constitute a significant health problem to 'welle' consumers because there is no M P L for Mn in meat (MFPO, 1973). Mensah (2001) reported increasing levels of Mn in the range of 2.7 mg/kg to 20.1 mg/kg for unsinged hides and 1.8 mg/kg to 30.7 mg/kg after singeing with scrap lorry tyres. The difference in the values in this study and those reported by Mensah (2001) for both unsinged and singed hides may be due to variations in mineral composition of soils, pasture and water sources on which these animals were raised (Lawrie, 1991) and the absence of wire stripes in motor tyres. The observed decreases in content of Mn in all the singed products also suggests that singeing (heat) may have some reduction effect which reduces the amount of Mn in the singed hides. This colloborates work done by Obiri-Danso *et al.* (2008) who reported decreases in the concentration of certain metals including Mn, Cu, Ni and Cd in singed 'welle'.

With respect to Cu and Zn, the fermented washed and boiled (Fwb) treatments recorded the highest values of 20.31 mg/kg and 35.31 mg/kg, whilst the tyre singed, washed and boiled (Twb) treatments had the lowest values of 1.88 mg/kg and 5.53 mg/kg respectively (Table 9). There were significant differences (P<0.05) among treatment means at all stages of the processing methods. However, there was no significant difference between the tyre-singed and washed (Tw) and the wood-singed and washed (Ww) values for Zn. Comparing these values to the MPL, (Fig. 3) Cu slightly exceeded its level of 20 mg/kg (MFPO, 1973) while Zn content was below its maximum limit of 50 mg/kg (USDA, 2006; ECR, 2006).

Figure 3; Metal contents in boiled forms of fermented, gas, tyre and wood treatments compared with MPLS of meat.



Traditionally, irrespective of processing method 'welle' is boiled before consumption. It was observed that the fermented washed and boiled products in this study generally recorded significantly higher values for Fe, Mn, Cu and Zn, compared to the singed products. Comparing the metal contents among all the singed products, wood-singed, washed and boiled (Wwb) 'welle' recorded the highest values for Cu (8.79 mg/kg), and Zn (10.69 mg/kg) whilst gas-singed washed and boiled (Gwb) 'welle' registered the highest values of 159.20 mg/kg for Fe and 10.48 mg/kg for Mn respectively, while the (Twb) treatment recorded the lowest values for Mn (5.84 mg/kg), Cu (1.88 mg/kg) and Zn (5.53 mg/kg). There seems to be no consistent trend in the Mn, Cu and Zn contents of 'welle' produced through singeing.

However, in the case of Fe, the trend was consistent irrespective of the processing method with fermented, washed and boiled 'welle'(Fwb) recording the highest value of 264.41mg/kg followed by gas-singed, washed and boiled hides (Gwb) (159.20mg/kg), tyre -singed, washed and boiled ‘welle’ (Twb) (80.11mg/kg), wood-singed, washed and boiled (Wwb) (73.13mg/kg); i.e. Fwb>Gwb >Twb> Wwb.

4.2 NUTRIENT COMPOSITION OF ‘WELLE’

The results of the nutritional analysis are shown in Table 10. Very high values of CP, with moderate values of EE and ash respectively were obtained.

Table 10: Effects of processing methods on Ash, Crude Protein (CP) and Ether Extract (EE) contents in ‘Welle’.

Nutrient (%)	Treatments				LSD	CV (%)
	Fermentation (F)	Gas (G)	Tyre (T)	Wood (W)		
Ash	1.67^{a}	1.17^{abc}	1.50^{a}	0.83^{c}	0.47	18.0
Crude Protein	93.60^{a}	85.60^{c}	92.03^{a}	90.37^{ab}	2.20	1.2
Ether extract	4.00^{d}	11.67^{a}	4.67^{c}	7.17^{b}	0.58	4.2

Means with different superscripts in the same row are significantly different at 5%

CV = Coefficient of Variation

LSD = Least Significant Difference

The percentage crude protein (CP) values for Fw, Gw Tw and Ww are 93.6, 85.60, 92.03 and 90.37 respectively. The values for fermentation and tyre- treated ‘welle’ were not significantly different at ($p>0.05$). There seemed to be some difference between the crude protein contents of tyre and wood treatments, but the observed differences were not statistically different ($p>0.05$). However, the CP contents for fermentation, tyre and wood treatments were all significantly different from that of gas. The differences may be due to differences in heat intensity from the different dehairing methods. Cross and Overby (1988) and Lawrie (1991) suggested that heat treatment influences the protein content of food substances. The heat intensity from the singing process as indicated by Girard (1992) results in the degradation of essential amino acids and also presumably vitamins. The crude protein values obtained in this study compare closely with those of Moore and Stein (1951), but did not agree with values reported by Ofori (2001) and Agbovi (2001) who obtained CP values (dry matter basis) in the range of 56.46 to 69.19 for 'welle'. The significantly higher CP value for Fw (93.6%) could be attributed directly to the non heat treatment during the fermentation process and possibly due to the activities and multiplication of anaerobic bacteria or microbes which may also add up to the total protein level. The Gw treatment recorded significantly ($p<0.05$) lower value (85.60mg/kg) and this is reflected in its significantly ($p<0.05$) higher either extract value (fat). Fat and protein contents of food materials are inversely related (Lawrie, 1991). The results of this study suggest that fermented samples have a relatively higher CP (93.6) compared with all the singed products i.e Gw (85.60), Tw (92.03) and Ww (90.37). Cattle hide contains collagen which is one of the few proteins which has hydroxyproline (12.8%) in its primary repeating structure; glycine-proline-hydroxyproline (Lawrie, 1991), which is responsible for the thermal stability of the collagen and hence the extent of heat processing has little effect on it and the amino acid contents and availability. Thus, though higher CP values have been reported the amino acid profile and its bioavailability remain issues for consideration in determining the actual nutritional value of 'welle'. Lawrie (1991) reported works by various researchers who recorded decreasing availability of lysine, tryptophan and methionine when meat was heated to 70^0C.

The percentage EE values for Fw, Gw, Tw and Ww are 4.00, 11.6, 4.67 and 7.67 respectively (Table10). There were significant difference ($p<0.05$) among treatment means. The differences observed might be due to the fact that the pieces of hide in this study were taken from different sides of the whole hides. The relatively lower EE values recorded with respect to their corresponding CP values might be attributed to the fact, that the procedure followed in the extraction of EE does not remove all the fats especially phospho-lipids or fats bound to proteins (McDonald *et al*., 1987).

Ash values for the Fw, Gw, Tw, and Ww treatments were 1.67, 1.17, 1.50 and 0.83 respectively (Table 10).There were no significant difference ($p>0.05$) between fermented and tyre-singed treatments. Though there seemed to be some difference between the ash contents of gas and tyre singed 'welle', the observed difference was statistically not different. ($p>0.05$). Similarly, the difference observed between the ash contents of gas and wood treatments were statistically not significant ($p>0.05$). These results are comparable to those of Ofori, (2001) who reported ash values for cattle hides treated with different singeing materials to be in the range of 1.33 to 1.94 mg/kg. The significant difference between the fermented, and gas and wood singed 'welle' could be linked to the heat used in the singed treatments.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1 SUMMARY AND CONCLUSION

The results of this study indicated that Pb and Cd were not present in any of the treatments (singed and fermented), The non detection of these heavy metals in both the fermented and singed hides could be attributed to the animal rearing/ environmental factors (soil, pasture, water sources, medication, etc) prevailing in Buipe. However, various levels of Fe, Zn, Mn and Cu were detected in all the treatments. The detected metals were, found to be below the maximum permissible limits and/or tolerable upper intake set by various food safety standards.

The nutritional analysis indicated that the 'welle' produced using the different dehairing methods contain very high levels of crude protein, moderate ether extract and ash contents. Furthermore, the dehairing methods used in processing hides (welle) appear to have some influence on the nutritional contents of the products.

It could thus be concluded that singeing hides with gas, motor cycle tyres or wood did not elevate metal concentrations in singed 'welle' compared with fermented 'welle', but rather reduced them. The extent of decrease observed for the detected metals was however dependent on the type of singeing materials. The consumption of 'welle' as a meat product in Northern Ghana might not have any health implications in view of the moderate metal contents in them. This could be attributed to the fact that most herds of cattle are kept and herded far away from towns where they are likely to pick up these metals. It may rather improve upon the general nutritional standard of 'welle' consumers, particularly pregnant and lactating mothers as well as infants in terms of mineral supplementation especially, for Fe, Mn, Cu and Zn.

5.2; RECOMMENDATIONS

1. In order to have a fair idea of the levels of heavy metals in our soils, pastures and waters, further investigations should be carried out on regional basis because the metals can enter the food chain through the live animals during grazing and watering.
2. The Agricultural Extention Agents and Veterinary personnel should intensify their education of local farmers and butchers on the use and disposal of agricultural chemicals and materials used in the singeing process in order to sustain the current low level of metals in ‘welle’.
3. The fermentation method of ‘welle’ production should be encouraged; since it is environmentally friendly and the resultant products have a high nutrient content. However, fresh cattle hides should be washed and put in clean polythene bags before they are fermented underground to avoid contamination.
4. The detailed profile of ‘welle’ especially that of the amino acids should be investigated to ascertain their bioavailability and nutritional benefits.
5. Finally sensory evaluation should be conducted with trained panelists in order to ascertain the organoleptic characteristics of ‘welle’.

REFERENCES

Aberle, E. D., Forrest, J .C., Gerrard, E and Mills, E. W. (2001). Principles of Meat Science. (4th Edition). Kendall Hunt Publishing Corporation, USA. Pp. 117 – 152.

ACS, (1997). Chemistry in Context: Applying Chemistry to Society (2nd Ed). WCB/McGraw-Hill, USA. Pp. 231-255.

ACS, (2003). JELL-O, The quintessential American dish is a part of everyone's childhood. Chemical and Engineering News. (202) 872-4600. (800) 227 - 5558.

Adegoke, G .O and Falade, G. O., (2005). Meat quality. Journal of Food, Agriculture and Environment, 3 (1): 87- 90.

Adu-Amankwa, P., (1999). Quality and Process Control in the Food Industry. GhanaEngineer, Accra,Ghana.GhanaEngineer,Accra,Ghana. www.africantechnology forum.com/GhIE/Food.

Agbovi , S. W, (2001). Chemical composition and microbial analysis of cattle hides dehaired using firewood, LPG, and old rubber tyres. A Dissertation submitted to the Department of Animal Science, Faculty of Agriculture KNUST, and Kumasi.

Amerine, M., Pangborn, R. M., Roessler, E. B, (1965). Principles of Sensory Evaluation of Food; cited by Adu-Amankwa, P. (1999). Quality and Process Control in the Food Industry. The Ghana Engineer, Accra, Ghana.

Ammann, H. M., (1986) "Health Implications of Wood Smoke" Proceedings ofthe International Conference on Residential Wood Combustion. Reno, Nevada. Pp. 1-15.

AMS, (1995). Poultry Grade Yields Report, Poultry Grading Branch, United States Department of Agriculture,Washington D.C. Pp. 4-6.

Anonymous, (2006). Montanans Against Toxic Burning. www.notoxicburning.org/fact 2006.htnl

Anonymous, (2003). Dietary references intakes. Application in dietary planning. Subcommittee on interpretation and uses of dietary references intakes and the standing committee on the specific evaluation of dietary intakes. Institute of Medicine and the National Academies Press. Washington D, C., Pp 248-256.

Appiah-Num, M. A. A., (2004). Determination of the levels of some essential and heavy metals (iron, zinc, lead, manganese, cadmium and copper) in meat of cattle, sheep and goats in the Kumasi metropolis; A dissertation submitted to the Department of Chemistry, Faculty of Science, KNUST, Kumasi. Pp 4-14.

APVMA. Definition of residue for the purpose of setting a MPL. Residue Guideline No. 6, 2000.

Asamoah-Frimpong, F., (2003). Heavy metal concentration of cattle hides (welle) from the singeing process; A dissertation submitted to the Department of Chemistry, Faculty of Science, KNUST, Kumasi. Pp. 12-17.

ASNS, (2003). Animal source foods to improve micronutrient nutrition in Developing Countries. J. Nutrition 133.4048S-4053S.

ASQC, (1998). Profile for Chlorinated Dibenzo-p-Dioxin (update). U.S Department of Health and Human Service, Public Health Services, Atlanta, Georgia, USA. Htpp:/atsdrl.atsdr.cdc.gov.8080.

ATSDR, (1998). Toxicological quality Systems Terminology, Milwuakee, Wisc USA. www.atsdr.cdc.gov/toxprofile/.

Baghurst, K., Record, S. and Leppard, R., (2000). "Red meat consumption in Australia, Intakes, nutrient contribution and changes overtime" Autralian Journal of Nutrition and Dietetics 57(4):1032-1322

Barrett, A. M.A., (2010). Added hormones in meat and dairy, do they affect health and if so, how? Third Age Media LLC. USA. Pp. 1-4.

Bastin, S., (2007), Nutrition Value of Meat: Co-op. Ext Service University of Kentucky - College of Agric. UK. Pp. 1-3

BCWG, (1999). "Base Convention Technical Guidelines on the identification and Management of Used Tyres" Base Convention on the Control of Trans-boundary Movements on Hazardous Wastes and their Disposal. Document No. 10. Pp. 2-9.

Bender, A.K and Zia, M., (1976). Meat quality and protein quality. Journal of Food Technology, 11:495 - 498

Bill, D., (2010). What are the benefits of meat products? 2011 Demand Media, Inc. LIVESTRONG.COM.htm.

Bonner, J., (1998). Hooked on drugs. New Scientist. http;//archive.newscientist.com.

Brewer, M. S and Prestat, C., (2002). Consumer attitudes toward food safety issues. Journal of Food Safety 22; 67-83.

Brewer, M. S and Lonergan , S., (2010). Consumer Attitudes; what they say and what they do. Cooperative Ext. Syst. U.S.A. Pp. 1- 8.

Brewer, M. S., (2011). Consumer Attitudes. What they say and what they do. www.extention.org / www.pork.org.

Brewer, M. S., Sprouls, G. K. and Russon, C., (1994). Consumer attitudes towards food safety issues. J. Food Safety, 14: 63-76.

Brown, F., (2009). Meat consumptions/capita. guardian.co.uk. Guardian News and Media Ltd 2011.

Callow, E. H., (1932). Annual Report, Food Investigation Board, London: Cited by Lawrie, (1991). Meat Science, 4th Ed. Pergamum Press Ltd, Oxford, England.

Callow, R., (2009). What nutrients are in meat? 2011 Bright Hub Inc. Pp. 2-3.

Campbell, A and Jopson, N., (2008). Alliance Meat Quality Trials. Alliance Group Ltd in association with ABACUS Bio Ltd, New Zealand. Pp. 1-4.

CAR, (2007). Burning Issues, http:/ /burningissues.org/ pdf/ WoodSmBroharris pdf.

Chambers IV, D and Bowers, J., (1993). Consumer perception of sensory qualities in muscle foods: sensory characteristics of meat influence consumer decisions. Food Technol. 47: 116 -120.

CHC, (2001). "the Real Dope on Beef Hormones" Duplisea, Bradford. Pp. 79-86.

CIWFT, (2004). Reducing Meat Consumption the Case for Urgent Reform, Hampshire, UK. www.ciwf.org. Pp. 1-4.

CIWMB, (1992). Tyres as a Fuel Supplement: Feasibility Study, Sacramento, Califonia, USA. Pp. 56-79

Cook, A and Kemm, J., (2004). Health Impact Assessment of Proposal to Burn tyres in a cement plant. Environmental Impact Assessment Review, Vol. 24 (2): 207 – 216.

Correa, J. E., (2010). Nutrition value of goat meat. Alabama Cooperative Extension System, USA. Pp. 1-3.

Costa, M., (2000). Trace Elements; aluminum, arsenic, cadmium and nickel. In Environmental Toxicants; Human Exposures and Their Health Effects, 2nd edition. John Wiley and Sons Inc. USA. Pp. 811- 850.

Crawford, M. A., (1975). Meat as a source of lipids: *In Meat* (Eds D.J.A. Cole and R.A. Lawrie). Butterworths, London, Pp 451-459.

Cross, H. R and Overby, A. J., (1988). Meat Science, Milk Science and Technology. Elsevier Science Publishers B.V. Amsterdam-Oxford-New York-Tokyo. Pp 127 -135.

Crossby, P. B., (1979). *Quality Is Free*, McGraw-Hil. New York USA. Pp. 21-32.

D'Mello, J. P. F., (2004). Contaminants and toxins in animal feeds; In assessing quality and safety of animal feeds. FAO Animal Production and Health 160. Food and Agricultural Organization of the United Nations, Rome, Italy. , Pp. 107-128

Devine, R., (2003). Meat consumption trends in the world and the EU. INRA Prod. Anim, 16: 325 - 327..

ECR, (2006). EC. No. 1881/2006. Setting maximum levels for certain contaminants in foodstuff. Official J. of the Euro Union: 5-24.

Elias, O and Ralph, B., (1996). Leather demand giving a boost to cattle hides exports. June/July, 1996 issue of AgExporter. FindArticles.com.

Essumang, D. K., Dodoo, D. K., Adokoh., K.C., Koka, V., Nkrumah, B.N and Nuer, A. C. D., (2007). Heavy metals in singed cattle hides (wele). Publ. First Internationa Conferencel on Environmental Research. ENTERP 2007. Accra, Ghana.

Estoe, J. E and Long, J. E., (1960). Amino acid composition of processed bone and meat meal; cited by Ravindran, V., Thomas, D.V., Morel, P.C.H. and Butts, C.A., (2005). Comparison of the ileal digestibility of amino acids in meat and bone meals for broiler chickens and grower rats. International J. Poultry Sc. 4 (4) 192-196.

Eurometaux, (2010). Which metals are essential for human health? European association of metals. eurometaux@ eurmetaux.be

Evans, T., (2010). European chicken meat consumption trend. 5M Enterprise Ltd, Benchmark House, 8 Smith Wood Drive Sheffield, S35IQN, England. Pp. 1-3.

FAD/WHO, (1985). Energy and Protein Requirements. Technical Report Series 724 WHO. Pp. 421- 436.

Fairfax County, (2008). Heavy metal pollution is more common than you think. Conservation Currents, North Virginia Soil and Water Conservation District Virginia. Pp. 2-5.

FAO, (1985). Manual of the slaughter of small ruminants in developing countries; section on slaughtering practices and techniques. FAO Animal Production and Health paper No 49. Pp. 51-55.

FAO, (2003). Global production and consumption of animal source foods. Journal of Nutrition, (11 suppl. 2) 4048S – 4053S: http;//-jn.nutrition.org.

FAO, (1990). Manual on Simple Methods of Meat Preservation Animal Production and Health Paper 96. Rome, Italy.

FAO, (1990c).Manual on Simple Methods of Meat Preservation. FAO, Animal Production and Health Paper 79. Rome, Italy.

FAO, (1992). Meat and Meat products in human nutrition in developing countries. FAO Corporate Document Repository.Viale delle Terme di Caracalla, 00100 Rome, Italy. Pp. 174-800.

Faribal, Z., Hossein, T., Siamak, A., Saeed, M., Aziz, A. F and Mohammad, R., (2009). Determination of Cu, Zn and Fe in edible muscles of three commercial fish species from Iranian Coastal Waters of the Caspian Sea. J. of Animal and Vet Advances. 8 (7): 1285 - 1288.

Farr, G., (2004) .The Hair Tissue Mineral Analysis/ Why Heavy Metals Are a Hazard to Your Health? BecomeHealthyNow.com

FEC, (2007). Meat consumption trends and environmental implications. Surrey Street, Brighton. UK. www.foodethicscouncil.org. Pp. 1-9

Fletcher, D. I., (1997). Quality of Poultry Meat Texture and Colour. Proceedings Georgia International Poultry, Athens. Pp. 113-117.

Friberg, L., Grunner, F. N and Velimer, B., (1979). "Handbook on toxicology of metals". Elsevier/Northe Holland Biomedical Press. Pp. 20-30.

FSANZ, (2002). Food Standards Code. Vol. 2. Canberra Information Australia, 2002.

GenStat Discovery Edn. 3. GenStat Procedure Library Release PL15.2. 2008.

GEPC, (2005). The market for Djembe drums in the USA. Market Briefs from GEPC. *htt://www.gepcghana.com*

Girard, J. P., (1992). Smoking Technology of Meat and Meat Products. Ellis Horwood, New York USA. Pp. 165 - 201.

Globe and Mail, (1999). Breast cancer linked to Beef. (www.sustainable .org /issues /hormones)

GMIA, (2001). Gelatin Information, History and More. C% Dorsery and Whitney LLP, 260 Park Avenue New York, NY 10177. Pp. 1-5.

Grassner, B and Wuethrich, A., (1994). Pharmacokinetic and toxicological aspects of the medication of beef-type calves with an oral formulation of chloramphenicol palmitate. Journal of Veterinary Pharmacology and Therapeutics 17: 279-83.

Gregory, N.G., (1992). Catching damage. Broiler Industry 55: 14 - 16.

Grunert, K.G., (2006). Future trends and consumer lifestyles with regard to meat consumption, 52nd International Congress of Meat Science and Technology, Dublin,Ireland. Pp. 513-611.

Hambal, A., (2003). Determination of levels of lead, cadmium, manganese, zinc and iron in cattle hides (wele) from the Singeing process using wood as fuel. A dissertation submitted to the Department of Chemistry, Faculty of Science, KNUST, Kumasi. Pp 3-11.

Hammond-Aryee, A. B. N. O., (2000). Investigation of cattle hides (wele) processing techniques and its lead, zinc, cadmium, manganese and iron content. A dissertation submitted to the Department of Chemistry, Faculty of Science, KNUST, Kumasi. Pp. 9-14.

Holder, C., Schneider, R., and Shirley, C., (1991). Toxics A-Z! A Guide to Everyday Pollution Hazards. Berkly, University of California Press.

Holland, H., (2011). The health benefits of eating red meat. 2011 Demand Media Inc. LIVESTRONG.COM.

House, C., (1991). Outbound quality of feed depends on inbound control.Feedstuffs, 63: (20) 5.

Hughes, P and Heritage, J., (2004). Antibiotics-Growth Promoters in food Animals. FAO, Animal Production and Health Paper, 2004. Pp. 152-160.

IAFC, STMC and NFPA, (2000).The Prevention and Management of Scrap Tyre Fires. Washington DC, USA. Pp. 1-50.

ICT, (2010); Hide and Skin quality. Leather Trade House, Northampton, UK. (http; //www. lethercouncil.org/fair).

IFF, (1986). *Quality Assurance in the feed industry*, IFF report. Publication No 2. Pub. Victam Int. AJ Venlo, Netherlands. Pp. 1-80

James, W.P.D. (1988). Healthy Nutrition. WHO Regional Publications, European Series No.24. Copenhagen, Denmark. Pp. 23-29.

Jayasekara, S., Samarajeewa,U. and Jayakody A.N (1992). Trace metals in foods of animal origin in Sri-lanka. ASEAN Food Journal, 7: 105 – 107.

Jensen, B.B., (2010). Alternative to Antibiotics as Growth Promoters. 5M Enterprises Ltd, Benchmark House 3, Sheffield, England. Pp. 1-3.

Juran, J. M., (1974). Quality Control Handbook, 3rd ed: McGraw Hill, New York. Pp. 43-47.

Kamaruzzaman, B. Y., Mohd, M. S. Z., Akba, B.J., Jatal, K.C.A., Shahbudin, S. Albarwani, S.M and Goddard, J.S., (2010). Bioaccumulation of some metals by green gussel Perna viridis (Linnaeus 1758) from Pekan, Pahang, Malaysia Int. J. Botany, 6; 54-60.

Kan, C. A and Meijer, G.A.L., (2007). The risk of contamination of food with toxic substances present in animal feed. Animal Feed Sci. Technol. 133: 84 -108.

Kilic, E., (2011). Heavy metal pollution in water, Hacettepe University- CAG KIMYA TURKEY. Pp. 1-3.

Kofranyi, E and Jekat, F.K., (1969). Hoppe-Seyler's Zeitschrift fur physiologische Chemie; cited by Lawrie (1991) Meat Science (5th Ed). Pergamon Press Oxford.New York. Seoul. Tokyo Pp. 225.

LANXESS, (2010).Hide as raw material. Lanxess Energizing Chemistry. www. Lanxessleather.com/lea/en/basics/rawhidesandskins/hidesasrawmaterial.

Lawless, H., (1991). The sense of smell in food quality and sensory evaluation. Journal of Food Quality 14: 33 - 60.

Lawrence, T. J. L., and Fowler, V.R., (1997). Growth of farm animals. New York: CAB International. Pp. 314 – 320.

Lawrie, R . A., (1991). Meat Science ,5th Ed, Pergamon Press, Oxford, New York, Seoul, Tokyo Pp. 225 – 232.

Leita, L., Enne, G., De Nobili, M and Sequi, P., (1991). Heavy metal bioaccumulation in lamb and sheep bred in smelting and mining areas of S.W. Sardinia, Italy. Food Sci. Technol. 24:125 - 127.

LWTPH, (2009). Heavy Metal/ www, lenntech.org.

Liu, P.I., (1993). An Introduction to Energy and Environment. Van Nostrand Reinhold, New York. USA.

Lydia, C., Medeiros, J. R.B., Ray, A. F., Janet, C.W., Glean, J. M and Betty H., (2002). Nutritional Content of Game. Cooperation Ext. Serv, College of Agriculture, University of Wyoming. Pp. 1-5.

Lyon, B. G and Lyon, C.E., (1991). Shear values ranges by Intron, Warner-Bratzler and single-blade Allo-Kramer devices that correspond to sensory tenderness. Poultry Science 70: 188-191.

MAFF, (1994). Radionuclides in food. Food Surveillance. Forty-third Report of Steering Group on Chemical Aspect of Food Surveillance. Paper No. 43. HMSO London, UK.

McAlpine, L., (2011). Vitamins and Minerals That Meat Give Us. Demand Media Inc. LIVESTRONG.com

McDonald, P., Edwards, R. A and Greenhalgh, I. F.D., (1987). Animal Nutrition. 4th Edn. Longman Scientifi and Technical Longman Group, UK Ltd., England. Pp.56-60.

Mensah, L., (2001). Heavy metal contamination of sheep and goat skin hide fromthe singeing process; A dissertation submitted to the Department of Chemistry, Faculty of Science, KNUST, Kumasi Pp. 9.

MFPO, (1973). The Gazette of Indian No. 112. Pp 111-200.

Moore, S and Stein, W, H., (1951), cited by Joane H.B, Elliot R.G, and Moss J.A. (1955). The composition of collagen and acid-soluble collagen of bovine skin. *British Leather Manufacturers Association Egham, Surrey.* 61:143-150.

MTPSI, (2005). Unpublished data on Skin/Leather Importation. Pp. 16-23

Mwinyihiya , M., (2008) Hides, skins and leather in Kenya. Leather International Magazine. Nov/Dec, 2008 edition. Pp. 30 – 32.

NOAH, (2001). Antibiotics for animals. http;// www.NOAH.co.uk/antibiotic.htm.

NRSAR,(2006-07).Definitions, abbreviation and acronyms. www.daff.au_data/assets/pdf_/file/0008.

NZFSA, (2007). Agricultural Compounds Residue in Food. www.nzfsa.gov't nz.

Obiri-Danso, K., Hogarh, J.N. and Antwi-Agyei, P. (2008). Assessment of the contamination of singed hides from cattle and goats by heavy metals in Ghana. African Journal for Environmental Science and Technology. 2 (8): 217-221.

OCES, (AGEC 603), (2007).Twenty-Five Year Meat Consumption and Price Trends. http://osufasts.okstate.edu

OECD, (2004).Emission Scenario Documents-Additives in the Rubber Industry Federal Environmental Agency, Berlin, Germany. Pp. 271-313.

Ofori, S.K., (2001). Effects of processing methods and storage conditions onthe microflora and chemical content of cattle skin 'wele'. A dissertation submitted to School of Graduate Studies, KNUST. Pp. 40-50.

OJEC, (77/1 COMMISSION REGULATION (EC) No. 466/2001. Setting Maximum Levels for certain contaminants in foodstuffs 8 march 2001. (16): 312-317.

Okiel, W., Ogunlesi, M., Alabi, F., Osiughwu, B and Sojinrin, A., (2009). Determination of toxic metal concentrations in flame treated meat products, *Ponmo* .African Journal of Biochemistry Research 3 (10): 332 - 339.

Oppong-Anane, K and Apori, S. O., (2007). Ghana's livestock skin; a delicacy or a raw material for leather. Proceedings of the 15th GSAP Conference. Pp 81-84.

Othman, F., (2006). Understanding Meats; Why red meat is red and white is white ?. http;//www.arteclealley.com/article.

Parley International, (1996). The importance of nutrients. Oslon Center for Women's Health, Canada. Pp. 111-114.

Pearson, I. J and Dutson T.R., (1990). Meat and Health. Advances in Meat Research. Vol. 6 Pp. 241-251.

Pechan, E. H and Associates Inc., (1997). Air Emission from scrap tyre combustion. A Report Prepared for the United States Environmental Protection Agency. Pp. 1-40

QFAC, (1997-2010). Dioxin and Toxins. QFAC.Com. Pp. 1-4.

Qiu, C. A. I., Long. M., Liu, J., Zhu. M., Zhou Q-Zhen., Deng ,Y.de Li Y, Tain Y-J., (2008). Correlation between heavy metal concentration in cattle tissues and rearing environment. Chinese J. of Ecol.27 (02); 202-207.

Raloff, J., (2002). 'Hormones: Environmental concerns reemerge over steroids given to livestock Science News 161 (1). Pp.10.

Ranjhan, S. K., (1997). Animal Nutrition in the Tropics, 4th ed.Vikas Publishing House, New Delhi, India.

Rano, L., (2008). US warming to air-chilled chicken. Decision News Media. Russell Agricultural Research Magazine,Athens, Georgia. Pp. 1-5

Reinmuth, G., (2010). B_{12}, Iron and Red Meat. 2011 Demand Media Inc. LIVESTRONG.com.htm

Reisman, J. I., (1997). Air emissions from scrap tyre combustion. United States Risk Management Environmental Protection Research Laboratory. Agency Cincinnati, OH452 68. EPA/600/SR-97/115. Pp. 1-4.

Resurreccion, A.V.A., (2002): Sensory aspects of consumer choices for meat and meat products. International Congress of Meat Science and Technology; Rome, Italy. Pp. 11-20.

Santhi, D., Balakrihsman, V and Kalaikannan, K. T., (2008). Presence of heavy metal in pork products in Chennai (India). An. J. Food Technol., 3 (3): 192-199.

Scollan, N., Hocquette, J. F., Nuemberg, K., Dannenberger, D., Richardson, I and Molonay, A., (2006). Inoculations in beef production systems that enhance nutritional and health value of beef lipids and their relationship with meat quality. 52nd International Congress of Meat Science and Technology (ICoMST); Aug 13-18; Dublin, Ireland.

SCVMPH, (1999) "Assessment of Potential Risk to Human Health from Hormone Residues in Bovine Meat and Meat Products" European Commission. Pp. 1-70.

Simm, G., Richardson, I., Nute, G., Edwards, S., Hunter, T and Barley, T., (2004). Whole Chain Approach: Factors Affecting Lamb Eating Quality. Final Report to SEERAD. Pp. 1-9.

Southgate, D. A. T., (1978). Meat, Fish, Eggs and Novel proteins; In Human Nutrition and Dietetics, 9th ed. Churchill Livingstone, New York, USA. Pp. 51-60.

Speedy, A.W., (2003). Global Production and Consumption of Animal Source Foods. Animal Production and Health Division, Food and Agriculture Organization of the United Nations, Rome Italy. Pp. 11-19.

Spika, J. S., Waterman, S. H and Soohoo, G.W., (1987). Chloramphenicol resistant Salmonella Newport traced though hamburger to dairy farms. New England Journal of Medicine, 316: 565 - 570.

Stancheva, M., Peycheva, K., Makedosnki, L and Rizov, T., (2010). Heavy metals and PCBs level of Blue fish (*Pomatomus saltatrix*) from Bulgarian Black Sea waters. Ovidius University Annals of Chemistry Vol. 2 No 1 Pp41-48.

Stephens, K.S., (1979). Preparing for Standardization, Certification and Quality Control. Asia Productivity Organization, Tokyo. Pp. 125.

Subramanyam, B., (2009). Pesticide management in the field and its relevance toresidues in feed grains.17th Annual ASAIM SEA Feed Technology Nutrition Workshop. Pp. 1-55.

T P M, (1992). Agency for Toxic substance and Disease Registry. ATSDR's Toxicological Profiles, Web Version CRC Press. United States.

Toxtown, (2010). Meat Processing in US, National Library of Medicine, 8600 Bethesda, MD, USA.

Tremblay, L., (2011). Vitamins, nutrients and minerals in meat. LIVE STRONG. COM.htm.

Trevor, J. H., Joseph, M. S and Harvey, W., (2010). Rethinking cull boar transport. Canadian Veterinary Journal. 51: 315 – 321.

US EPA, (1994). Health Assessment Document for 2, 3, 7, 8- Tetrachlorinated Dibenzo- p-dioxin (TCDD) and related compounds. (1994 report, Final report). Washington DC EPA/600/BP-92a (NTIS PB94205465) 1994.

USDA, (2006). Foreign Agricultural Services GAIN Report; Global GAIN Report No. CH6064, Chinese People's Republic of FAIRS products. Specific maximum levels of contaminants in foods, Jim Butterworth and Wu Bugang. Pp. 1-60.

USFA, (1999). Report on tyre fires submitted to Committee on Commerce, Science and Transportation, United States Senate on Committee Science, United States. House of Representative, Pp. 12 - 14.

Verbeke, W., Van Oeckel, M.J., Warnants, N., Viaene, J and Boucque, C.V. (1999). Consumer perception, facts and possibilities to improve acceptability of health and sensory characteristics of pork. Meat science, 53(2): 77-99.

Voegborloh, R. B and Chirgawi, M. B., (2007). Heavy metal accumulation in roadside soil and vegetation along a major highway in Libya. Journal of Science and Technology. Kumasi, Ghana 27. (3): 86-97.

VSD, (2005). Unpublished data on importation of bovine hide. Accra, Ghana. Pp. 21-30.

Warner, L.R., Sokhi R.S., Luhana, L., Boulter, P. G., McCrae, I., Wright, J., Reeves, N. and Osbon, D. (2002). Non-exhaust particle measurements, http://vergina.eng.auth.gr/particles/.

Whitney, E. N and Cataldo, C. B., (1983). Understandarding Normal and Clinical Nutrition. West Publishing Co., Pp4.

Williams, P., Droulez, V and Levy, G., (2002). Nutrient composition of Australian red meat. Gross Composition Data of Food. 58: 173-81.

Williams, P.G., (2007). Nutrient Composition of Red Meat. http:// ro. Uow .edu .au / hbspapers/48

Wolfe, K., (1998). Consumer Preferences and Low No-fat Food. Agricultural Development Center. ADC Info No. 26.

Zaibet, L., Mtimet, N., Hammami, S., Khammassi, M and Ammar, A., (2007). Assessing meat product quality; a consumer perception approach. Ecole Superieure d'Agriculture, Mograne (ESAM), 1121, Zaghouan, Tunisia.

Ziegler, P.T., (1968). The Meat We Eat. The Interstate Printers and Publishers, Inc. Danville, Illinois. Pp. 69-71.

APPENDICES

TABLE 1 ANALYSIS OF METALS IN THE VARIOUS PROCESSING METHODS OF WELLE MADE (IN TRIPLICATES)

Sample N^{O}.	1	2	3	4	5	6	7	8	9	Test unit	IDL
description	Fu1	Fu2	Fu3	Fw1	Fw2	Fw3	Fwb1	Fwb2	Fwb3		
Fe	196.16	196.40	196.40	169.64	169.60	169.52	264.44	264.42	264.36	g/kg	0.0060
Mu	40.08	39.92	40.12	22.60	22.52	22.68	21.04	20.92	20.88	mg/kg	0.0020
Cu	4.36	4.28	4.36	4.44	4.36	4.24	20.26	20.24	20.32	mg/kg	0.0030
Zn	22.84	22.88	22.76	21.64	21.72	21.64	35.36	35.28	35.28	mg/kg	0.0010
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	mg/kg	0.0010
Cd	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	mg/kg	0.0020

Sample N^{O}	10	11	12	13	14	15	16	17	18	Test unit	IDL
Description	Wu1	Wu2	Wu3	Ww1	Ww2	Ww3	Wwb1	Wwb2	Wwb3		
Fe	170.96	170.84	170.88	200.36	200.32	200.24	74.16	73.08	73.16	mg/kg	0.0060
Mn	11.20	11.28	11.24	10.44	10.36	10.44	5.92	5.88	5.80	mg/kg	0.0020
Cu	0.52	0.52	0.48	0.16	0.20	0.20	8.88	8.72	8.76	mg/kg	0.0030
Zn	3.40	3.28	3.20	2.96	2.96	2.96	10.68	10.64	10.76	mg/kg	0.0010
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	mg/kg	0.0010
Cd	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	mg/kg	0.0020

Table 1 Cont'd

Sample N^{O}.	19	20	21	22	23	24	25	26	27	Test unit	IDL
Description	Tu1	Tu2	Tu3	Tw1	Tw2	Tw3	Twb1	Twb2	Twb3		
Fe	92.00	92.16	92.20	180.68	180.80	180.84	80.08	80.12	80.12	mg/kg	0.0060
Mn	7.36	7.36	7.44	10.12	10.12	10.04	5.88	5.88	5.76	mg/kg	0.0020
Cu	0.32	0.32	0.32	1.24	1.16	1.16	1.92	1.96	1.76	mg/kg	0.0030
Zn	7.28	7.24	7.36	4.44	4.28	4.40	5.64	5.44	5.52	mg/kg	0.0010
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	mg/kg	0.0010
Cd	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	mg/kg	0.0020
Sample N^{O}.	28	29	30	31	32	33	34	35	36	Test unit	IDL
Description	Gu1	Gu2	Gu3	Gw1	Gw2	Gw3	Gwb1	Gwb2	Gwb3		
Fe	75.84	75.64	75.80	146.00	146.04	146.12	159.12	159.24	159.24	mg/kg	0.0060
Mn	6.40	6.56	6.56	8.68	8.80	8.76	10.48	10.40	10.48	mg/kg	0.0020
Cu	8.64	8.76	8.64	3.32	3.16	3.28	2.80	2.88	2.88	mg/kg	0.0030
Zn	8.72	8,92	8.80	10.44	10.44	10.52	10.04	10.00	10.04	mg/kg	0.0010
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	mg/kg	0.0010
Cd	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	mg/kg	0.0020

IDL=Instrument Detecting Limit
(u_1, u_2, u_3), (w_1, w_2, w_3), (wb_1, wb_2, wb_3) are unwashed, washed and washed and boiled replicates of the fermented (F), Wood

(W), Tyre (T), and Gas (G) treatments.

TABLE 2 : QUALITY CONTROL AND REFERENCE STANDARDS ANALYSIS

1 ELEMENT (Fe)	Ref.std. 1	Ref.std. 2	Ref.std. 3	Qc.std	4 ELEMENT (Pb)	Ref.std 1	Ref.std. 2	Ref.std. 3	Qc.std
CONCENTRATION (Mg/I)	2.000	5.000	10.000	4.988	CONCENTRATION (Mg/I)	2.000	5.000	10.000	4.938
MEAN ABSORBANCE	0.1529	0.3670	0.8243	0.366	MEAN ABSORBANCE	0.0739	0.1924	0.3558	0.1900
% PRECISION	1.1	1.0	0.9		% PRECISION	1.0	0.7	0.5	
%RECOVERY				99.76	% RECOVERY				98.76
2 ELEMENT (Cd)	Ref.std. 1	Ref.std. 2	Ref.std. 3	Qc.std	5 ELEMENT (Mn)	Ref.std 1	Ref.std. 2	Ref.std. 3	Qc.std
CONCENTRATION (mg/I)	0.500	2.000	3.000	1.968	CONCENTRATION (mg/I)	1.000	2.000	5.000	1.977
MEAN ABSORBANCE	0.1712	0.6565	0.9850	0.6460	MEAN ABSORBANCE	0.1902	0.3401	0.8623	0.3362
% PRECISION	1.0	0.6	0.3	98.40	% PRECISION	1.9	0.9	0.6	
%RECOVERY					%RECOVERY				98.85
3 ELEMENT (Cu)	Ref.std. 1	Ref.std. 2	Ref.std. 3	Qc.std	6 ELEMENT (Zn)	Ref.std 1	Ref.std. 2	Ref.std. 3	QC. std
CONCENTRATION (mg/I)	2.000	5.000	8.000	4.983	CONCENTRATION (mg/I)	0.250	0.500	1.000	0.491
MEAN ABSORBANCE	0.2749	0.6999	1.0080	0.6975	MEAN ABSORBANCE	01645	0.3377	0.6541	0.3316
% PRECISION	1.2	1.2	0.6		% PRECISION	0.6	0.9	0.3	
%RECOVERY				99.66	%RECOVERY				98.2

TABLE 3: ANOVA for Fe Values

Source	DF	SS	MS	V.R(F-Value)	F.pr(P-Value)
Process	3	4.67E+04	1.557E.04	2.593E+06	<0.001
Washing	2	1.056E.+04	5.280E+03	8.796E+05	<0.001
Process, washing	6	6.059E+04	1.010E+04	1.682E+06	<0.001
Residual (Error)	24	1.441E+01	6.003E+03		
Total	35	1.178E+05			

Coefficient of variation (CV) = 0.1%

TABLE 4: ANOVA for Mn Values

Source	DF	SS	MS	V.R(F-Value)	F.pr(P-Value)
Process	3	2.537E+03	8.458E+02	1.903E+05	<0.001
Washing	2	1.84E+02	9.240E+01	20790.63	<0.001
Process washing	6	5.885E+02	9.808E+01	22068.14	<0.001
Residual	24	1.067E.01	3.311E+03		
Total	35	3.311E+03			

CV (%) = 0.5

TABLE 5: ANOVA for Cu values

Sources	DF	SS	MS	V.R	F pr
Process	3	3.581E+02	1.94E+02	29194.99	<0.001
Washing	2	2.610E+02	1.305E+02	31916.23	<0.001
Process. Washing	6	4.593E+02	7.654E+01	18719.52	<0.001
Residual	24	9.813E-02	4.089E-03		
Total	35	1.078E+03			

CV (%) = 1.4

TABLE 6: ANOVA for Zn VALUES

Source	DF	SS	MS	V.R	F.pr
Process	3	2.680E+03	8.932E+02	1.932E+05	<0.001
Washing	2	2.174E+02	1.087E+02	23514.14	<0.001
Process Washing	6	2.578E+02	4.297E+01	9296.12	<0.001
residual	24	1.109E-01	4.622E-03		
Total	35	3.155E+03			

TABLE 7: ASH, CRUDE PROTEIN AND ETHER EXTRACT IN CATTLE HIDES (WELLE) OF THE VARIOUS PROCESSING METHODS MADE (IN TRIPLICATES)

Sample code	% CP	% EE	% ASH
Gw 1	80.50	15	1.50
Gw2	94.30	6.00	0.50
Gw3	82.00	14.00	1.50
Tw1	93.00	2.00	1.50
Tw2	95.10	1.50	1.50
Tw3	88.00	10.50	1.50
Ww1	87.00	10.00	0.50
Ww2	92.3	5.50	1.00
Ww3	91.8	6.00	1.00
Fw1	96.4	1.50	1.00
Fw2	92.1	5.50	2.00
Fw3	92.3	5.00	2.00

TABLE 8: ANOVA for CP values

Source	DF	SS	MS	V.R	F.pro
Rep stratum	2	6.695	3.347	2.76	
Rep Units stratum					
Treatment	3	107.847	35.949	29.63	<.001
Residual	6	7.278	1.213		
Total	11	121.820			

Cv(%) = 1.2

TABLE 9: ANOVA for ASH values

Source	DF	SS	MS	V.R	F.pr
Rep stratum	2	0.16667	0.08333	1.50	
Rep *units* stratum			0.1042		
Treatment	3	1.22917	0.40972	7.38	0.019
Residual	6	0.333333	0.05556		
Total	11	1.72917			

Cv (%) = 18.2

TABLE 10: ANOVA for EE values

Source	DF	SS	MS	V.R	F.pr
Rep stratum	2	2.00	1.0	12.0	
Rep *unit* stratum					
Treatment	3	108.56	36.19	434.25	<.001
Residual	6	0.50	0.08		
Total	11	111.06			

CV (%) =4.2