UNIVERSITY FOR DEVELOPMENT STUDIES

AN ASSESSMENT OF SLAUGHTERHOUSES AND SLAUGHTERING PROCEDURES IN NORTHERN GHANA

OSMAN FUSEINI

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AN ASSESSMENT OF SLAUGHTERHOUSES AND SLAUGHTERING PROCEDURES IN NORTHERN GHANA

BY

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A THESIS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY (MEAT SCIENCE AND TECHNOLOGY) DEGREE

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DECLARATION

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

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DEDICATION

I dedicate this work to the Lord Almighty Allah for given me life and good health. I also dedicate this to my dear parents; Mr. and Mrs. Fuseini for their tremendous support, prayers and love shown me throughout this study. Finally, I dedicate this work to my lovely wife and three sons for their love for me.

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I am very thankful to Almighty Allah for the wisdom, protection and good health granted me throughout the period of this study notwithstanding the challenges I went through.

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ABSTRACT

The study was conducted to assess the infrastructure and slaughtering procedures of slaughterhouses in the three Northern Regions of Ghana. Twenty slaughterhouses were visited to obtain data for this work. The facilities of the slaughterhouses were evaluated based on their presence and functional status. About 80.0% of the slaughterhouses were deficient in certain facilities and the few (20.0%) slaughterhouses with infrastructure were in dilapidated state. It was observed that, the state of the slaughterhouses were not good enough for the processing of animals for human consumption. The association between the size of the slaughterhouses and the number of animals slaughtered and processed for meat daily was statistically non-significant ($P>0.05$). Ninety five percent (95.0%) of the slaughterhouses had no functional pipe-borne water therefore butchers' sourced water from head porters and other available water sources. Also, majority (90.0%) of the slaughterhouses were not provided with electricity. The absence of electricity and portable water supply coupled with the poor status and unhygienic conditions of these slaughterhouses raise serious public health concerns, as hygiene problem are not only limited to slaughtering but are also associated with incorrect processing. There were no functional lairages in majority (60.0%) of the slaughterhouses, as a result ante-mortem inspections were not carried out. Post-mortem inspections were carried out in seventeen slaughterhouses representing 85.0%. The slaughterhouses visited slaughtered fewer number of animals as compared with those in standard abattoirs. The method of restraint prior to slaughter was rude, as it involved physical struggle between animals and slaughterers. None of the slaughterhouses visited representing (0.0%) engaged in proper waste management systems. As such, waste was found littered all over

the surroundings of the slaughterhouses which comprises mostly of bones, hides and rumen content. It was observed that, 85.0% of workers in the slaughterhouses did not observed safety rules and regulations. For example, in the observation of safety rules and regulations, 45.0% of the slaughterhouses had its workers used aprons while 100% did not used safety gears like helmets, nose and mouth mask and goggles. Again, 40.0% of the slaughterhouses had its workers using safety boots while 5.0% had a fire extinguisher. None of the slaughterhouses representing 0.0% had its workers engaged in proper hand washing and disinfection. Also, none of the slaughterhouses representing (0.0%) had meat or cold vans during this study. Butchers resorted to the use of inappropriate means such as motor tricycles, motor bikes and bicycles to transport meat to meat shops.

Generally, the infrastructure and slaughter operations were below standards in all the slaughterhouses visited.

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LIST OF ABBREVIATIONS AND ACRONYMS

1. AFRSC.....Australia Food Regulation Standing Committee
2. CAC.....Codex Alimentarius Commission
3. CBP.....Captive Bolt Pistol
4. CCPs.....Critical Control Points
5. CBPP.....Contagious Bovine PleuroPneumonia
6. DFD.....Dark Firm Dried
7. DARD.....Department of Agriculture and Rural Development
8. EU.....European Union
9. EEG.....Electroencephalogram
10. FDA.....Food and Drug Administration
11. FRS.....Functional Requirements Specification
12. FAO.....Food and Agricultural Organization
13. FSA.....Food Standard Agency
14. GWCL.....Ghana Water Company Limited
15. HACCPs.....Hazard Analysis Critical Control Points
16. LPG.....Liquefied Petroleum Gas
17. MTU.....Meat Technology Update

18. NR.....Northern Region

19. OIE.....World Organisation for Animal Health

20. PE-LD.....Low Density Poly Ethylene

21. PE-HD.....High Density Poly Ethylene

22. PP.....Polypropylene

23. PHC.....Population and Housing Census

24. PHAC.....Public Health Agency of Canada

25. PPE.....Personal Protection Equipment

26. PSE.....Pale Soft Exudative

27. RMAA.....Red Meat Abattoir Associations

28. SARI.....Savannah Agricultural Research Institute

29. SPSS.....Statistical Package for Social Sciences

30. T.B.....Tuberculosis

31. UER.....Upper East Region

32. UWR.....Upper West Region

33. WHO.....World Health Organization

34. WPO.....World Packaging Organization

CHAPTER ONE

INTRODUCTION

1.0 Background to the study

A slaughterhouse is a facility designed and licensed for receiving, holding, slaughtering and inspecting meat animals and meat products before release for public consumption (Alonge, 2005). It may also be define as a place where animals are slaughtered or butchered for food. The slaughtering of animals for human consumption is important in most nations of the world and dates back to ancient times (Bello and Oyedemi, 2009). Slaughterhouses exist primarily to provide the appropriate environment for slaughtering livestock and controlling waste spill (Ofosu-Koranteng, 2010).

The Ghana Food and Drugs Authority (FDA) requires any facility being used as an abattoir to have equipments for slaughtering, holding, processing, storing and distribution of carcass to various meat shops. For a slaughterhouse or abattoir to be able to provide wholesome meat to the public, a number of guidelines need to be followed: These guidelines indicate the steps to be followed to ensure that meat are wholesome for human consumption. These guidelines are:

- Slaughterhouses should be sited away from human settlement.
- Slaughtering of livestock should take place in a facility that has been properly registered by the authority/agency that is mandated to do so.
- Slaughtering of livestock should be done under proper hygienic conditions as inspected and approved by the controlling authority.
- The facility should have all the appropriate equipment for the various stages of livestock processing.

- The facility should have various sections for slaughter operations such as stunning section, bleeding section, evisceration section, carcass splitting section, condemned section, laboratory, washrooms and offices.
- The facility should have a proper waste management system.

These are the guidelines that are deemed appropriate by the regulating authority as that which will ensure that wholesome meat is produced for human consumption under acceptable hygienic conditions and practices (Ofosu-Koranteng, 2010).

1.1 Statement of the problem

Slaughterhouses are facilities established to provide wholesome/hygienic meat for public consumption. These facilities are supposed to operate following some laid down rules and regulations by a regulatory body (FDA) to provide the populace with quality meat and meat products. This is supported by the FDA guideline FDA/APBD/CP-SH/2013/08 which is one of many guidelines, laws and regulations for the operation of slaughterhouses in Ghana.

These regulations provide the criteria for maintaining minimum standards at the abattoirs based upon which the abattoirs will be inspected and certified. These minimum standards cover the following:

- State and nature of infrastructure to include equipment, source of water and the regularity of supply, source of electricity, the drainage system in place and how effluent is discharged.
- The state and availability of storage and transportation facilities of the abattoir.

- The number of Veterinary Officers available at post and records on both ante-mortem of the animal and post-mortem carcass inspections.
- Hygiene and general certification of working personnel.
- Sanitary conditions of the slaughterhouse both interior and exterior.

These guidelines are important to protecting human lives and avoiding the spread of any infection that might be due to the consumption of meat slaughtered under unhygienic conditions. In Ghana and for that matter the northern sector, the putting into practice of these guidelines are important considering that animals are slaughtered and meat sold in the open markets without much consideration to any of the guidelines that calls for proper storage of slaughtered animals. Infrastructure plays a major role in providing wholesome meat and meat products to consumers but slaughterhouses in northern Ghana are deficient in most infrastructures and basic operating facilities and this is a hindrance to providing quality meat to consumers. A number of veterinary surgeons confessed that some slaughterhouses were lacking basic facilities to enable them carry out effective slaughtering activities (Olugaza *et al.*, 2000). Also, animal slaughtering and processing are done at the same point amidst affluent discharges, pools of blood and water used in washing the carcasses. Again, the slaughtering activities of animals take place in dilapidated structures, under very poor environmental conditions and there is little or no monitoring of the equipment being used and the slaughtering processes. Finally, the slaughterhouses are lacking meat vans for carcass transportation as a result they transport carcasses using the boots of taxis, motorise tricycles, on motorcycles and bicycles.

1.2 Justification of the study

Studies on meat processing in slaughterhouses are very crucial considering that meat has become a major component of the daily food consumption of the average Ghanaian. According to Walker *et al.* (2005) the demand for meat in developing countries continues to grow as production and consumption of meat increases with available income. The three northern regions (Upper east, Upper west and Northern) which make up northern Ghana are considered the poorest in Ghana (Shepherd, 2009). The improvement of infrastructure, slaughtering processing and sanitary conditions of the slaughterhouses in northern Ghana can form part of the strategy for alleviating poverty in the northern sector. This can be achieved if more people especially the rich who do not consume meat and meat products from the slaughterhouses because of the poor sanitary state and unwholesome manner in which meat are produced will now see the need to purchase and consume meat from such facilities. When this happens, it will help increase the butchers' earnings due to increase slaughter and consequently lead to improvement in quality of life of the butchers, slaughterers and animal producers.

The choice of study area for this research work was also critical because meats from these slaughterhouses are sold at the major cities and markets in the study areas.

Considering the population and the number of people from the study areas who consume meat produced from such facilities, the facilities needs to be properly equipped and upgraded to standard abattoirs in order to slaughter animals to serve the ever growing populations in those areas.

This study therefore sought to assess the infrastructure and slaughtering operations of slaughterhouses in northern Ghana.

1.3 Objectives of the study

The main objective of the study was to assess the current conditions of infrastructure and slaughter procedures of slaughterhouses in the three northern regions of Ghana.

1.3.1 Specific objectives:

- To assess the influence of size of slaughterhouses on number of animals processed for meat daily.
- To find out the current state of equipment and their functionality.
- To find out the extent of adherence of safety rules and regulations by workers in the slaughterhouses.
- To examine whether or not butchers follow the appropriate slaughter procedures in meat production.

1.4 Research questions

In order to achieve the objectives of the study, the researcher was guided by a number of research questions which included but not limited to the following:

- What is the influence of the size of slaughterhouse on number of animals slaughtered daily?
- What is the current state of equipment and are those equipment functional?
- Do workers in slaughterhouses adhere to safety rules and regulations?
- Do butchers follow the appropriate slaughter procedures in producing meat in the slaughterhouses?

CHAPTER TWO

LITERATURE REVIEW

2.1 Infrastructure and planning of slaughterhouses

Infrastructures with regard to slaughterhouses are logistics and facilities put in place to ensure the smooth running and operation of slaughtering activities. For a slaughterhouse to be recognized and certified as a meat producing facility it must meet certain requirements as far as the building, equipment, personnel and the environment is concern. In the developed world, slaughterhouses are considered important and are given the needed attention since they are seen as places where human foods are processed for consumption. Some strict rules and regulations are obeyed by slaughterers and butchers from those in authority to ensure that meat sent out to the public are safe for human consumption. As a result diseases that are acquired by people due to the consumption of contaminated meat in the developed world may be less than in the developing world due to differences in sanitary and slaughtering practices. However, it is the reverse in the developing world and for that matter Ghana. With the exception of few abattoirs that to some extent are fully equipped with infrastructure, observed good slaughter practices and hygiene, many slaughterhouses processed animals for meat under very poor environmental conditions and with very limited resources. In less commercial abattoirs with little machinery available, there is high human-animal interaction which can be a cause of stress to the animals due to fear of humans (Breue *et al.,* 2000; Hemsworth, 2003; Waiblinger *et al.,* 2006). In Ghana, few slaughterhouses are equipped with the needed resources to operate as abattoirs, the rest are operating with limited resources and under poor environmental conditions. With the limited resources, they are unable to meet

the requirement necessary for meat production and as such produce low quality and unwholesome meat. Different abattoirs have different facilities and management systems which can affect the quality of meat differently (Mummed and Webb, 2015). This makes most people especially the rich shy away from meat produce from those slaughter facilities and result to individual slaughter in their homes or import meat from other places where they think animals are slaughtered under good sanitary and management conditions.

Below are some infrastructures required in a slaughterhouse for its smooth operations:

- A well designed building that is spacious enough to contain most equipment and bigger animals at the same time.
- A building that must stand the taste of time.
- A building that has sections for various meat processing such as stunning unit, bleeding unit, singeing/scalding unit, evisceration unit, meat packaging unit and effluent treatment unit.
- Other sections should include; laboratory, store room, bathrooms/toilets, carcass/meat condemn section, cold room and offices for management.
- A well designed floor to promote easy cleaning but not slippery.
- A well designed guttery/drainage systems.
- Well-designed windows for proper ventilation.
- Preferably it must be provided with concrete and cement walls and given a good finished with oily paint for easy cleaning.
- It must be provided with a well-designed roof with iron beams and provided with ceiling.

- A fence to prevent unauthorized persons and animals from accessing the interior part of it.
- A well designed lairage for animals' rest and comfort.
- It must be provided with electricity and generators for power supply.
- It must be provided with water and water storage facilities for slaughtering operations.
- The entrance to the slaughter section must be sloppy but not slippery.
- It must be provided with a cold van for meat transportation.

2.2 Factors to consider in the construction/design of slaughterhouses

To construct a slaughterhouse, a competent architect, engineer, or other person experienced in slaughterhouse designs should be contacted to prepare drawings and specifications (Ofosu-Koranteng, 2010). A person with high technical knowhow should be employed to put the design into a real building. The design should be such that it ensures correct sequence of operation that encourages efficiency and discouraging contamination and cross-contamination (Igwe and Yakubu, 2000; Igwe 2005). In the plan, provisions must be made for the type of animals to be processed for meat. It should be specified clearly whether slaughtering will be based on only small ruminants or both small and bigger animals like cattle and buffalos. It is this decision that will give an engineer or an architect the idea about the type of materials to use in the construction of the facility.

Drawings must be to scale and include the following (Ofosu-Koranteng, 2010; Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).

a) A site plan showing the boundaries of the slaughterhouse property; location of the facility in respect to other buildings or structures; streets; driveways and parking sites including drainage systems and surfacing materials (e.g. gravel, pavement etc.); railway lines; sewer lines; potable water sources (e.g. wells); gas and water mains; and power lines. The scale and the north point should be shown;

b) A floor plan of each level of the plant, showing the purpose for which each room is to be used, location of walls, windows, doors, conveyor rails and all equipment on the floor or in an elevated position, (e.g. draw-off fans, refrigeration units), hose bibs, sanitizers and hand washing points.

c) A floor plan showing location and size of floor drains, location and size of direct drains for pieces of equipment using large amounts of water; curbing, gutters and slope of floor towards drains and the hot and cold water outlets.

d) The exterior elevations of the building, showing doors, windows, and platforms;

e) A cross section of the plant showing ceiling heights.

f) A roof plan showing skylights, vents, drainage and other pertinent information.

g) A schedule of room "finishes" must be on or attached to the plans, including a schedule of door sizes, construction and type of door frame and lighting intensity for each room.

h) An equipment layout with accompanying "flow charts" of operations. The design and construction of the equipment must be shown and where necessary, cross-sections provided to show method of construction and operation.

i) Where the plans refer to alterations or changes within an existing plant, sufficient description should be made of the surrounding rooms as well as those above and below.

Copies of plans of the existing layout and construction should be attached to explain the nature, extent, and effect of proposed changes.

2.2.1 Factors to consider when siting a slaughterhouse

Ideally, a slaughterhouse should be sited away from human settlements and water bodies because of the stench and the waste that is generated from it. In the developed world, wastes generated from slaughterhouses are channelled into generating power or biogas to help in the operation of the facilities. This is supported by Rabah *et al.* (2010) who mentioned that although abattoir waste carries high levels of microbes that may be harmful to humans; they are an excellent substrate for generating biogas. The slaughterhouse should be situated in areas where flooding is unlikely to occur and linked with free access for animals to the site by road. Where the slaughterhouse is constructed should be clear and free of bushes and vegetation within the vicinity. Likely future commercial and residential developments should be taken into account (Ofosu-Koranteng, 2010). The site should be accessible from a permanent road to allow ready transport of both livestock and meat. However in northern Ghana, slaughterhouses are sited within or very close to human settlements. As a result wastes generated from such slaughterhouses are piled up within its premises or are channelled into water bodies and the stench very disturbing to people closer to the facilities. The waste also pollutes the water bodies and renders it unsafe for human consumption. The piled up waste also attracts stray animals such as wild dogs, cats, pigs and vultures. It is therefore important that slaughterhouses be sited far away from human settlements as well as water bodies.

2.2.2 Size of the slaughterhouse

An ideal slaughterhouse must be relatively big and spacious enough to contain most equipment that is required for the operation of the facility. The number of animals to be killed and process for meat daily must be taken into account the size of the slaughter facility. Also the type of animals to be slaughtered must be taken into consideration when designing the slaughterhouse. The type of animals will determine the type of materials to use during the construction of the facility. Bigger and heavier animals such as cattle and buffalo will require heavy materials and large size building as compared with smaller animals such as goats and sheep. The slaughter area should also be spacious enough for smooth running of activities in that unit. However in northern Ghana, majority of the slaughterhouses are relatively small and are lacking most basic infrastructure and equipment for its operation. Also, most slaughtering activities are carried out in slaughter slabs which are even more devastating when it comes to infrastructure and hygiene. As such they processed few animals daily for meat when compared with the number of animals processed daily for meat in abattoirs such as Kumasi and Tema. The environments in which the animals are slaughtered are in poor state and could pose serious health problems to consumers.

2.2.3 Building / facility

Facilities involved in meat production and processing should be seen as places which stand for good sanitation and hygiene. In line with this, materials that are to be used in the construction of the building must be quality and standard. The walls and ceilings must be smooth, level, hard and consist of impervious material such as accepted prefabricated panels and glazed tile, and free from pitting, indentations, cracks, crevices and ledges

(Ofosu-Koranteng, 2010). All corners and junctions of walls and floors must be coved in kill floor, coolers, condemned and processing areas, and other areas subject to frequent cleaning and moisture. To promote light reflection and sanitation, wall and ceiling surfaces should be white or light-coloured. Whenever practical, materials that do not require painting should be used. Materials that are absorbent and difficult to keep clean must not be used. Examples of unacceptable materials include wood, plasterboard and porous acoustic-type boards. Walls should be provided with suitable sanitary-type bumpers or sloped curbs to protect them from damage by hand trucks or lifters (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012).

2.2.4 Floors of the slaughterhouse

The floor of the slaughterhouse serves as one of the major source of carcass contamination. The flooring should be hard, free of cracks, evenly levelled and impervious, and sloping adequately towards a drain to allow easy cleaning with water and disinfection. Also, bricks, floor tiles and waterproof materials are good for flooring. Wooden floors are not suitable for use at areas in the slaughterhouse where water is always pouring on the floor. This type of floor will easily get rotten as a result of the constant cleaning with water and other fluids. However smooth flooring should not be encourage as this reduces friction and personnel working there can easily slip and fall. Thus, tiles are not recommended for the slaughtering area (National Meat Inspection Service, 2013).

2.2.5 Walls of the slaughterhouse

The walls should be at least six (6) inches in diameter and made of cement and concrete blocks. The interior and exterior part of the walls must be smooth enough to be easily

cleaned by water, and recommended materials are stones, lava blocks and bricks or concrete (Ofosu-Koranteng, 2010). There should not be a chance for rodents and reptiles to easily climb to the inside of the slaughterhouse. The interior part of the walls may be finished with polished tiles to facilitate cleaning and to prevent rodents from moving on it. Internal wall surfaces should be durable and easy to clean and finish with light color paint (National Meat Inspection Service, 2013). A clear example of the way the interior part of the walls of slaughter sections in slaughterhouses should be can be seen in plate 1.

Plate 1: The interior walls of Bawku abattoir finished with polish tiles

2.2.6 Roofing/Ceiling of the slaughterhouse

The roof of the facility should be of best quality. Roofing materials should not be heat absorptive to make workers uncomfortable during sunny days. Materials such as a galvanized aluminium zinc, concrete slates and concrete decks will be appropriate for

roofing (National Meat Inspection Service, 2013). By providing a concrete deck, there will not be the need for ceiling. Metal beams are excellent in roofing high buildings. A 4x6 and 2x6 inches insect resistant woods will be suitable for the roofing in slaughterhouses where metal beams will not be used. Materials for the roofing must be rust free and moisture-resistant. Ceilings should be made up of plywood or other equivalent materials (National Meat Inspection Service, 2013) and be at least 3.5m in height. Ceilings of rooms intended for livestock receiving, slaughtering and dressing should be at least 5.0m in height. The roofing should be done in such a way that provisions will be made for collecting or harvesting rain water for the operation of the facility. In abattoirs or slaughterhouses where firewood is used as fuel for providing fire for both singeing and scalding within the building, provisions (a chimney) must be made on the roof for smoke to escape to the outside.

2.2.7 Drains in the slaughterhouse

Slaughterhouses generate a lot of waste especially liquid waste during slaughtering activities. To carry away these liquid wastes, there should be sufficient drains of the right sizes that are correctly located, trapped and vented (Ofosu-Koranteng, 2010). All floors in the slaughterhouse should be sloped toward the drains to enhance easy cleaning and proper flow of liquid waste. The drains should be properly constructed with adequate materials for easy cleaning and for it to stand the test of time. Plate 2 showed clearly drains in the slaughter section of the Wa slaughterhouse. The design (shallow and tilted nature) of the drains made cleaning easier for cleaners after slaughter activities.

Plate 2: Drains in the slaughter section of the Wa slaughterhouse

2.2.8 Lighting system in the slaughterhouses

As a matter of hygiene, the slaughterhouse should have a proper lighting system inside the slaughter line to allow proper functioning and to avoid accidents. Moreover, it will act as a deterrent to insects and rodents (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012). Bright light bulbs should be provided to make sure that the slaughter line is bright enough to avoid accidents in the hall. A standby generator or a solar panel with the right capacity may be provided to power the plant during periods of electric power fluctuations or outrages.

2.2.9 Ventilation system in the slaughterhouse

The internal temperature of the slaughterhouse should be maintained to prevent breeding of unwanted microorganisms and also to cater for a good working environment. The facility must be provided with enough windows and openings to ensure effective ventilation. Ventilation must be as appropriate as possible to reduce the atmospheric microbial load and to prevent stuffiness in the facility which can cause sweating and sneezing (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012). Also, it should be noted that larger window sizes will ensure effectual ventilation in the facility.

2.2.10 Doors and doorways

All doors in the slaughterhouse must be constructed with materials that will last long enough. Materials such as a well-cured mahogany wood or any wood of best quality should be used in making the doors (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012). Metal bars are also suitable and durable for making doors and windows. Nonetheless glass doors will not be an option considering the pressure and the activities going on in the slaughter plants. Doors in the slaughter area should be constructed wide enough to prevent carcass from touching the surfaces of the frame when it is been carried out or in to avoid possible contamination. The doors and doorways must be given a good finish with an oily paint to avoid rust if they are made of metal or to avoid insect attack when made with wood. All doors must be provided with quality hinges to hold the doors firmly to the frames. The thickness of the door frames should be at least 2 inches. Broken doors should be quickly replaced or repaired to avoid unauthorized people from getting access to the slaughter area. The fenced wall should

have at least two doors made of rust resistant metals and given a good finish with an oily paint. The gate doors should be curved with metal sheets to prevent small-sized animals from having access to the yard of the facility.

2.2.11 Windows of the slaughterhouse

Like the doors, materials of best quality must be used to prepare the window frames. Also, the thickness of the frame should be 2 inches or more. The windows should be constructed wide enough for proper ventilation. Windows at the stunning and bleeding area should be double-screened and be at least 0.6 m high and 0.4 m from the bottom of the roof beam (National Meat Inspection Service, 2013). It should be given a good finished with oily paint to promote its appearance and to resist water. It should be covered with a wire mesh to prevent reptiles, rodents or birds from getting access to the inside of the halls. Outside windows of the facility should not be made a hinged type of window for complete opening and closure. As this may be an easy route for rodents and insects.

A standard abattoir in terms of equipment must be provided with at least the following:

- Stunning equipment. Example stunning box for various sized animals and stunning guns.
- Bleeding equipment such as knives of different sizes, blood catching trough and bleeding machines.
- Butchering equipment such as knives, axes, meat saw and butchering machines
- Singeing/scalding equipment. Example scalding barrel or tank, torch or flame for singeing.
- Skinning/evisceration equipment. Example knives/axes and skinning machines

- Shackling or railing equipment. Example hog or hay hook, bleeding hooks
- Decapitating equipment
- Meat packaging equipment
- Laboratory equipment
- Weighing equipment
- Working platforms
- A cold van(s) for meat delivery

Protective/safety wears in the abattoir/slaughter house

- White apron
- Boots
- Goggles
- Helmet
- Gloves
- Nose/mouth mask

2.2.12 Equipment used in the slaughterhouse

For a slaughterhouse to be considered as standard and is able to meet its slaughter capacity, it must have adequate infrastructure and equipment. In the developed world, it is easier to identify a modern or a standard abattoir due to the infrastructure and equipment it is provided with. Modern and sophisticated machines and equipment are provided in such facilities to ensure that they meet their daily slaughter in other to meet the demand of consumers. A well designed slaughterhouse must have at least all the above mentioned equipment and facilities for quality meat delivery. However, in northern Ghana where this piece of research was carried out, majority of meat providing units are

slaughter slabs. This slaughter slabs lack even the most basic of equipment for meat production.

As a result of lack of equipment, most slaughter activities are carried out on the bare floor of the slaughter slabs. The lack of equipment also constraints butchers compelling them to slaughter lesser number of animals as compared with those in the abattoirs. For effective meat production in the slaughterhouses, it is important that they are well equipped with infrastructure and modern equipment. Ideally, the equipment to be used in meat production and processing lines should be made of non-corrosive materials, for example stainless steel. Equipment such as tables, hooks and machines should be positioned such that, they will be easy to relocate to facilitate cleaning and disinfection. The key step for the hygienic handling of carcasses is the equipment for elevating the carcass when slaughtered. In the processing line, cranes are preferred to working tables due to hygienic practices. Procedures that provide for the regular cleaning of hoists should be implemented and should be adhered to. Sophisticated equipment or machines require people with the right technical knowhow; as such the right people should be employed to operate them. Due to this, equipment that may be easily unassembled for easy relocation are preferred (Ofosu-Koranteng, 2010).

2.3 Sanitation in the slaughterhouse

Sanitation in the slaughterhouse is very important considering that it is a meat producing venture that needs to be constantly clean in order to attract customers to purchase the meat produced from it. Cleanliness in the slaughterhouse is necessary if we actually expect quality and healthy products for consumers. Sanitation has different meanings

depending on the context in which it is used. It can be generally defined as the unhygienic means of promoting of health through prevention of human contact with the hazards of waste. Such hazards can be physical, microbiological, biological or chemical agents (Hui *et al.,* 2003). In slaughterhouse practices, basic operating and environmental conditions of good sanitary and good hygienic practices as well as standard operating procedures are needed for the production of safe meat (Declan, 2004). The slaughterhouse should be constructed in such a way as to respect all the norms and regulations and planned such that all processes runs smoothly without contaminating or hindering the quality of the end product. The major goal for the food processing industries is to provide safe, wholesome and acceptable food to the consumer and control of microorganisms are essential to meet this objective (Baggen-Ravn *et al*., 2003). In line with this, a slaughterhouse should be designed to ensure the flow of operations from the live animal holding area through to discharge areas. Carcasses should be handled with much care right from the period of sticking until the final product leaves the slaughterhouse. Edible and inedible products should be separated and handled with caution to prevent possible contamination in the production line.

Bovine carcasses can be contaminated during the slaughter process through the contact with the animal's skin and hair, limbs, blood, stomach, gut contents, bile and other excretions, facilities, equipment and hands and worker's clothes (Sofos, 2008). The viscera (both paunch and pluck) of animals slaughtered should be properly removed and separated from the main carcass. If such is observed the possibility of content of the viscera spilling and contaminating the carcass will be reduced or eliminated. Primarily there are several key factors that a slaughterhouse should observe to satisfy the necessary

conditions which will contribute to adequate sanitation for the prevention of contamination. Below are some of the factors:

- Healthy animals must be passed as fit for slaughter.
- The floor of the slaughterhouse should always be clean and dry after slaughter operations.
- Ante-mortem and post-mortem inspections must always be carried out.
- Slaughter equipment should always be clean and sterilized.
- Carcass must not be allowed to touch the floor of the slaughterhouse.
- Protective gears must always be used during slaughter operations.
- A well insulated cold van must be used to transport carcass from the slaughterhouse.
- Clean water must be used during slaughtering activities.
- Car tyres and other dangerous materials should not be used for singeing of carcass.

2.3.1 Water supply system in the slaughterhouses

An adequate water supply is essential in slaughter facilities. That is portable water should be made available all the time for full operation of the slaughterhouse. While portable pipe-borne water is preferred, well or borehole water will also be suitable provided the water meets drinking standards. Agbogbu *et al.* (2005) opined that, the source of water supply for slaughtering activities is a major concern, as contaminated water contributes to the pathogenic microorganisms (aerobic bacteria, *coliform, faecal streptococcus*). Adzitey *et al.* (2011) reported that majority of butchers in Ghana process their beef carcasses with unclean water on the bare floor of the slaughterhouses which are most of

the time smeared with blood, rumen contents and other waste from previous dressing. The water to be used for cleaning activities in the slaughterhouses must meet drinking water standards (Fonseca *et al.,* 2000).

For hygienic reasons majority of work and activities in the slaughterhouse requires the use of water. Operation points such as washing of very dirty animals, slaughtering, scalding, washing of carcass, sterilizing hand tools, washing or cleaning of the floors and equipment and finally bathing by personnel who were involved during the slaughtering operations all needs water to carry out these activities. Quantities of water used in the slaughterhouse are discharged as effluent. This is supported by the findings of Amoah *et al.* (2003) who reported that at red meat abattoirs, water is used primarily for washing carcasses during the various processing stages and cleaning at the end shift, 80 to 95 percent of water used in abattoirs is discharged as effluent. In some areas it may be necessary to rely on rainwater collected from the slaughterhouse roofs. Under these circumstances water usage will need to be much lower than given above and dry slaughter systems should be adopted. Since slaughtering is a process which generates a lot of waste, to cater for the good running of the processes and minimize contamination, there should be a good supply of water of drinking quality to allow processing and cleaning procedures which will ensure healthy products. Working routines should be planned in such a way as to economically use the consumption of water during effluent discharges (Kirby *et al.,* 2003). It is also important to ensure that water storage vessels are properly covered, and cleaned regularly to maintain the water in a portable state. Contaminated water is a means for the transmission of several agents of diseases and continues to cause significant outbreaks of diseases both in developed and developing

countries (Kirby and Carl, 2003). An abundant supply of portable water as well as adequate facilities for treatment and disposal is important in the slaughterhouse. If water and energy supplies are sufficient it will be the responsibility of management of the slaughterhouse to see that these supplies are used efficiently and that sufficient water and energy are used for hygienic purposes. At the Salaga slaughterhouse, the only bore-hole meant for supplying water for slaughter activities was smeared with cow dung. This was seen as unhygienic as water from this may contaminate the carcass during washing.

Plate 3: A borehole smeared with cow dung meant for supplying water at Salaga slaughterhouse

2.3.2 Sanitary facilities in the slaughterhouse

In the slaughterhouse, sterilizers and disinfectants for hand tools, hoses and cleaning equipment are keys to providing a good standard of hygiene and these must be sufficiently provided. The provision of hot water for disinfection is preferred to chemical disinfectants during sanitary activities in the slaughterhouse. Provisions should be made for hand washing preferably under running water coupled with detergents and hand sanitizers. Sanitary facilities must also include an adequate number of toilets and arrangements for changing of clothes, hand-washing and even for bathing (showering). Such facilities must be clean and well-kept at all times and the toilets should possess hand wash basins along with soap, disinfectants, antiseptics, nailbrushes and clean towels readily available (Ofosu-Koranteng, 2010).

2.3.3 Personnel hygiene

For meat to be produced wholesome, the personnel in charge of the processing should be hygienic themselves. Personnel with clean hands, clothing and good hygiene practices are absolutely essential to the production of high-quality foods. The following are good hygienic practices that slaughterers and butchers can adopt to produce wholesome meat for public consumption (Ofosu-Koranteng, 2010).

- All clothing should be cleaned, in good repair and made of washable material. White or light-coloured clothing is most desirable and garments that become contaminated or soiled should be changed for a clean one or change another one completely.

- Personnel directly involved with meat processing should not wear any kind of jewellery, badges or buttons that may come loose and be accidentally included in the product or get pulled by equipment in the working area.
- Safety wears such as aprons, hand gloves and wrist guards must be made of impervious material, clean and in good repair. On no account should leather aprons and gloves be worn unless clean.
- Safety shoes and boots should be worn at all times and should be appropriate for the operations being conducted. These wears should also be made of impervious materials.
- Personnel should make sure that their hairs are not left loose. Hairs and nails should be clipped and hair gear or cap worn especially women to avoid loose hair from falling into the meat product. Also, to avoid loose hair from clinging unto a machine or an equipment during operations.
- Hands should be frequently washed under running hot water and always after visiting the toilet, smoking, coughing or sneezing, handling money, soiled or infected material. Particular attention should be paid to cleaning under the fingernails with a brush.
- Footwear should be waterproof so that it can be washed frequently and always when moving from one part of the slaughterhouse to another.
- If necessary mouth cover should be worn to avoid introducing saliva into the product when talking whiles working.

2.4 Environmental hygiene in the slaughterhouse

For the health of the environment and the surrounding communities where the slaughterhouses are located, slaughter facilities should be constructed outside residential areas. DARD (2009) opined that large amount of wastewater, solid waste, bad odour and fuel burning emission can be produced from slaughter operations which can affect the health of people living in the surrounding areas. Environmental hygiene starts with the place where the slaughterhouse is situated. As in all sectors of hygiene, the external and internal environment of the slaughterhouse should be protected against any possible agent of infestation. The design of the slaughterhouse should be adequately planned to prevent the easy entry of pest such as flies, rodents, birds, cats and dogs which serves as vectors of infectious diseases. This agrees with the findings of Olsen and Hammack (2000) who attested that insects, birds and rodents have been recognized as important carriers of pathogens and other microorganisms. The surroundings should be cleared of bushes meters away from the slaughterhouse and stagnant waters drained to ensure that the place is clean and dry. The main components of environmental hygiene will consist of the following;

2.4.1 Proper fencing

The slaughterhouse should be given proper fencing with the right materials. The fence should be constructed preferably with a concrete wall, supported or backed with iron bars and given a good finish with a waterproof paint. The fence should be constructed with a height of at least 3.4m high to prevent human beings and animals from scaling or jumping over it. The fencing should be firmly fixed to the ground and should be sufficiently high to deny unauthorized persons and animals from having access into the

premises (Urban and Broce, 2000). Insects, birds and rodents have been recognized as important carriers of pathogens and other microorganisms (Urban and Broce, 2000).

2.4.2 Pests control

Pest (insects, rodents and birds) should be controlled to prevent their access to slaughterhouses, production areas and storage departments. This is best achieved by the construction of buildings and working places where access of insects, rodents and birds are hindered, but it will be almost impossible to secure buildings totally against pest. However, good design and construction may delay the entry of pests which is a worthwhile objective of an overall rodent program. Even if the buildings are well-constructed and as pest-proof as possible it will be necessary to have a regular pest control. Best control systems for pest must include the following: (CAC, 1997b)

- Good Hygienic Practices should be used to avoid creating an environment conducive for pests.
- Pest control programmes could include preventing access to principal site, eliminating harbourage and establishing monitoring detection and eradication systems.
- Physical, chemical and biological agents should be properly applied by suitably qualified personnel.

2.4.3 Bird control

Birds that get access to the premises of slaughterhouses can be sources of contaminants either through their body surfaces or droppings. Birds like vultures are often found scavenging around the premises of slaughter plants especially in the rubbish dumps where they feed on decaying matter. The rubbish dumps which often serve as a source of

feed for such birds should be sited far away or should even be non-existent. The waste should be channelled into biogas production and other useful products that can serve the plant and if possible the nearby communities. Birds are often attracted by food supplies, water, special vegetation around buildings, and these attractions should be removed. The best control is to prevent them from accessing the buildings by placing nets on the openings and windows. For instance at the Wa slaughterhouse (Plate 2), vultures were seen scavenging on decayed rumen content and other waste products at carcass washing point.

Plate 4: Carcass washing point at the Wa slaughterhouse engulfed by vultures

2.5 Slaughter stock

Slaughter stocks are referred to animals that are brought to the slaughterhouse for slaughter. Animals that have just arrived at the slaughterhouse should be made to rest

adequately before slaughter. This is done to help improve upon meat quality and acceptability. The very dirty animals must be given a thorough bath to reduce the rate of cross contamination when slaughtered. It has been reported by MTU (2010) that carcass contamination is significantly lower following contact with clean hides than following contact with faecally soiled hide that had been washed prior to slaughter. A significant source of carcasses contamination results from the animals themselves (Aberle *et al.*, 2001). Animals ready to be slaughtered must be kept clean and should not be slaughtered in the view of other animals (Ernest, 2015). Basic equipment needed for the slaughtering operation such as stunning gun, knives and machete may all acts as sources of contamination during slaughter. Care must therefore be taken to ensure that all slaughtering equipment are sanitized at any point during the slaughtering operations. Animals must be stunned by humane method prior to slaughter. Stunning if properly done makes animals temporarily unconscious so that they will not feel pain during sticking. This reduces struggling of the animal and makes it less hazardous for the operator and also promotes effective bleeding.

2.5.1The welfare of slaughter stock

Animal brutality is a growing issue of concern in many countries around the globe. The cruelty by which animals suffer in the hands of farmers to butchering is alarming and needs serious attention to curb the situation. As such the welfare of meat animals has become a topical issue when it comes to meat production especially in the developed world. The ways animals are handled have great influence on the quality of their meat (Adzitey, 2011). Frimpong *et al.* (2012) reported that the abattoir system in the developed world is quite different from that in the developing world. They went further to state that

while the abattoir system in the developed world provides services that are geared towards meat quality, most of the abattoir systems in the developing countries including Kumasi abattoir in Ghana provide services for butchers focusing on the quantity of meat required without due consideration of meat safety and quality. In the developed world, animal welfare is increasingly becoming a primary matter in the process of keeping animals either as pets or for food. Not only are they protecting the rights of these animals but poor animal handling has adverse effects on the animal, carcass and meat quality. Carcass and meat quality defects such as pale soft exudative, dark firm dry, skin blemish, bruising, high microbial load, spoilage of meat, broken bones and death may occur from improper animal handling (Forrest, 2010; Warriss, 2000; Adzitey *et al*., 2011). Poor quality animal and meat will have poor processing properties, functional quality, eating quality and more likely to be unaccepted by consumers. Lesser attention has been paid by most developing countries on this issue. It is therefore important that developing countries like Ghana take interest in proper pre-slaughter handling of animals due to their beneficial effects on meat and carcass qualities. Loading and unloading of animals should be carried out with the appropriate techniques to avoid welfare issues. Frimpong *et al.* (2012) reported that in most cases animals were lashed with sticks during the process of loading and unloading at the Kumasi abattoir.

2.5.2 Welfare of stock during transport

Animals in Ghana are normally challenged with a lot of stressful situations during transport. They are transported on open trucks, motor cycles, tricycles or bicycles and others trek on foot for very long distances even during extremes of weather, with minimal chances of grazing, drinking water and resting. Frimpong *et al.* (2012) attested that long

journey of cattle, especially without rest, affects the welfare of slaughter animals. The stressful conditions through which the animals experienced have been proven by literature to have deleterious effects on the quality of the animals, carcasses and meat. This is supported by the findings of Chambers and Grandin, (2001) who reported that, poor transportation can have serious deleterious effects on the welfare of livestock and can lead to significant loss of quality and production. Hemsworth *et al.* (2011) supported that, stress experienced during routine handling and restrained procedures reduces productivity and apart from causing poor meat quality and economic losses, has negative implications on animal welfare. The commonly observed means of animal transport in Ghana and perhaps other West African countries is by road and on articulator or cargo trucks. These trucks move from farm to farm or market to market to load animals to the slaughterhouses or to other market centres within the country or other West African countries. As result of the inter-country movement by these trucks, animals have to endure long hours of travel compromising their welfare. Frimpong *et al.* (2012) reported in a study that in the animal supply chain of Kumasi abattoir, the slaughter animals were transported for a longer period up to 37 hours on average. This has negative implication for animal welfare. For example European regulation concerning animal welfare imposes that no animal should stay more than 8 hours on a vehicle without rest.

2.5.3 Welfare of stock during lairaging

A lairage is provided for animal rest on arrival at the slaughterhouse. Caring for animals in the lairage is very important as it promotes meat quality and avoids welfare issues. Nonetheless the lairage system is yet to gain recognition in Ghana as most slaughter houses are not provided with lairages. Animals awaiting slaughter are most of the time

tethered to trees and other permanent structures in the slaughterhouses. A well designed lairage should have pens where different kinds of animals can be kept for rest. It should be walled and provided with shade to prevent direct sunlight from making the animals uncomfortable. Provision should be made for enough ventilation in the lairage to prevent bad odour from the urine and droppings of the animals. Feed and water should be made available especially for animals that will stay in the lairage for more than 24 hours. Drinking water should always be available to the animals in the lairage (Shimshony and Chaudry, 2005).

However, the absence of lairage facilities raises welfare concerns with regard to the treatment meted out on animals in slaughterhouses without lairages. For instance, putting animals from different farms together in the same pen can lead to fighting among them. This causes bruising as they gore, bite and kick each other. It can even lead to death depending on the magnitude of the fight and the kind of animals involved. Also lack of feed and water for animals in the slaughterhouses may lead to dehydration and starvation which consequently results in emaciation and sometimes death. According to Immonen (2000), physical stress by hunger, fatigue, lesions, besides the physiological stress, can lead to depletion of muscle glycogen reserves and propitiate the incidence of dark, firm and dry (DFD) meat. Chambers and Grandin, (2001) had it that, long term stress causes DFD meat which has a shorter shelf life. Also, severe short term stress results in a Pale, Soft and Exudative (PSE) meat. PSE meat has a pH lower than normal ultimate value of 6.2 which is responsible for the breakdown of proteins, providing a favourable medium for the growth of bacteria (Miller, 2002). It is the responsibility of the abattoir to ensure minimal stress and good animal welfare from the time the animals arrive at the abattoir to

the time of slaughter (Red Meat Abattoir Association, 2011). Lack of space in the lairage can be a welfare issue since most animals' especially small ruminants needs space to lie down. Cattles seldom lie but sheep and goat lie down to rest especially during the night. In addition, allowing animals in a lairage without a shade would not meet a proper lairage requirement and that animals would have to stay under the mercy of the weather until when they are needed for slaughter. A proper lairage system must meet the requirement to ensure that animals are comfortably housed and fed. Bedding materials must be provided to ensure that animals feel more comfortable lying down. Feed and water must be provided *ad-libitum* and withdraw at least twelve hours before they are taken for slaughter. Also, ante-mortem inspection must be carried out on animals whilst in the lairage to make sure that diseased animals are not slaughtered for meat. For the safety of the animals and the quality of meat expected from animals, a lairage should not be used to accommodate different kinds of animals as observed in some slaughterhouses during the study. Plate 3 is a typical example as bigger and smaller ruminants were put together in the same lairage at the Bolgatanga abattoir. This can cause stampede during feeding which can lead to bruising and possibly death of weaker and smaller animals.

Plate 5: A lairage serving both smaller and bigger ruminants at the Bolgatanga abattoir

2.5.4 Welfare of animals during slaughtering

The final destination of an animal is the slaughtering point. That is when the carotid artery and the jugular veins are finally severed by slicing the throat with the help of a sharp knife or a machine to effect bleeding. Before and during the bleeding action, care must be taken to avoid welfare issues. Animals ready to be slaughtered must be restraint to restrict its movement in order to facilitate effective bleeding. Also, animals must be stunned to cause immediate loss of consciousness which lasts until it is bled. Unconsciousness prevents animals from experiencing pain during bleeding prior to its death. In most slaughterhouses in Ghana, stunning operations are not practiced. Sometimes, animals and slaughterers have to struggle at the point of restraining them prior to bleeding. Chambers and Grandin (2001) opined that raw meat quality is reported to be severely affected by the stress conditions during slaughtering processes and the slaughtering methods. Again in the slaughter line, animals are sometimes slaughtered in

the full glare of their mates. The sight of their mates being slaughtered in their presence may put fear and panic in them especially when they see the pool of blood all over the floor. Fear and pain are very strong causes of stress in livestock and stress affects the quality of meat obtained from this livestock (Chambers and Grandin, 2001).

2.6 Meat inspection (ante-mortem and post-mortem)

It is expected that meat meant for human consumption be declare healthy or wholesome by qualified meat inspectors. For this to be achieved, the meat animal must be examined thoroughly by officials in charge of animal health whiles it is still alive (ante-mortem). Production of wholesome meat starts right from the lairage during which animals are put through inspection by a qualified veterinarian to identify diseased-animals and cull them and allow disease-free or healthy animals into the meat chain. During the ante-mortem inspection, the veterinary officer in charge must make sure that animals brought from farms and the markets are put in the lairages or a place where the inspection can be carried out effectively. Ante-mortem inspection can be used to indicate animal welfare right from the farm, through transportation to lairaging. This agrees with the findings of Shimshony and Chaudry (2005) who reported that ante-mortem inspection can be used as a measure to determine pig welfare at the farm, during transportation, at unloading and during rest in pens. The ante-mortem inspection must look out for the following in a live animal:

- Bruises on the skin
- Breathing difficulties
- Fractured limbs

- Broken horns and hooves
- Ability to stand or not

After the ante-mortem inspection, the animal will either be accepted into the meat chain or rejected depending on the judgment passed by the veterinary officer. If an animal is passed fit into the meat chain, it is then sent into the slaughtering or bleeding hall where stunning is carried out prior to bleeding. After bleeding and evisceration, post-mortem inspection is carried out. With this, the veterinary officer or trained meat inspector examines both the viscera and the carcass thoroughly for possible infections. Depending on geographical location or country and the laws governing meat production, offal may be considered edible or inedible. In other places the animal head and feet are all considered as waste and meant for the dust bin or channel into animal feed processing. However, as observed in some slaughterhouses in Ghana, the head and feet are well appreciated as a delicacy and the only time it is considered a waste is when it is infected beyond trimmings by meat inspectors or butchers. On the contrary this is not the case with some other international countries like Canada for example, where they are regarded as waste material and are therefore condemned (Bianchi *et al.,* 2005). White (2006) reported that meat trimmings can account for an average loss of 2 kg in every 1000 kg pig slaughtered (0.2%). Besides meat loss, meat trimmings would be time consuming, increases the work load of meat inspectors and interrupts the normal operation of slaughterhouses (Adzitey and Huda, 2012). With the post-mortem inspection, the meat inspector checks thoroughly the internal organs such as the lungs, heart, liver, spleen, pancreas and the brains for possible infections. The meat inspector or the veterinarian thoroughly examines the lymph nodes in the various organs for possible infections.

However it should be noted that the viscera and the carcass are not placed on the same platform for examination or inspection. This is to prevent cross contamination. After the carcass has gone through post-mortem inspection, the whole carcass or halves is stamped to indicate that it is passed fit for consumption. On the other hand unfit carcass are rejected and condemned. Trimmings are practices that should be performed by trained butchers and it consists of the removal of portions of meat that are contaminated beyond human consumption. The process of pig slaughtering involves pig transportation, unloading to the lairage, veterinary ante-mortem inspection, stunning, dressing, veterinary post-mortem inspection, stamping and delivery (Moreno Garcia, 2003). All equipment (hooks and knives) should be sanitized between each use to reduce cross-contamination between areas (Reij *et al.,* 2003).

2.7 Transportation of animals to slaughter plants

Animals that are slaughtered for meat in the slaughter plants are either from farms, markets or from individual animal owners. According to Wariss (2000), getting animals from farm to abattoir forms the first link in the chain of meat production and one which is both important and to some degree, contentious, important because it can influence carcass and lean meat quality and contentious because the processes of handling and transport provide many opportunities for the animal's welfare to be compromised. Adzitey (2011) reported that, pre-slaughter animal handling starts right from the farm, through marketing and end at the slaughter line. Farm animals are transported several times during their life time and most are transported to slaughter, often over long distances, both within and between countries (Appleby, 2011) and it is an exceptionally

stressful as it compromises their welfare (Knowles and Warriss, 2000). Transportation begins with loading and ends with unloading. Both ought to be done in a gentle manner and under a quieter environmental condition (Adzitey and Nurul, 2011). In northern Ghana and for that matter Tamale, animals are transported through divergent means to slaughterhouses. Individual animals' especially small animals are normally transported on bicycles or tricycles and some are pulled to the facilities by rope. Group of animals' especially big and heavy animals like cattle are transported using trucks and these trucks sometimes do not meet the requirement for animal transportation. Most of the trucks are open and also not spacious enough for transporting larger number of heavy animals at a time. All necessary precautions during transportation should be considered to minimize stress and injury to the animals. This is important because when animals are injured prior to slaughter, they may grow sick and this can result in an unplanned death. Also when animals are stressed, it is observed that their meat is usually of less quality as compared to when they are well rested and relaxed before slaughter. Stress experienced during routine handling and restraint procedures reduces productivity and apart from causing poor meat quality and economic losses, stress has negative implications on animal welfare (Hemsworth *et al*., 2011). Research has shown that better quality meat with a longer shelf life can be produced if animals are handled with greater patience, understanding and care at slaughter (Red Meat Animal Association, 2011). Road transport is probably cheaper and more convenient means for conveying animals.

Below are some precautions that are worthwhile noting during road transportation of the animals to slaughter:

- The trucks should not be under-loaded or overloaded: under-loading results in animals being thrown around and falling more than necessary whiles overloading causes stress and bruising due to crushing. The way in which animals are loaded, unloaded as well as the way in which a vehicle is driven can have enormous effects on the welfare of transported animals (Broom, 2005).
- Animals should not be transported during the hottest part of the day.
- The road to be used for the transportation should be smooth and not bumpy. According to Grandin (2008), a 500 km trip on a smooth highway will probably be less stressful than a 100 km trip on a rough or jumpy dirty road that takes the same length of time.
- The truck should be provided with sufficient ventilation and lighting.
- Drivers should not negotiate corners at excessive speed and must accelerate and decelerate gently. This is supported by the findings of Broom (2008) who reported that careful driving, especially on bends and corners on route and during acceleration and braking have a substantial effect on the welfare of cattle.
- For open trucks the top should be covered with a tarpaulin to protect the animals from bad weather conditions.
- They should be equipped with appropriate loading and unloading mechanisms to prevent injuries and stress. The loading and unloading procedures should be improved as poor procedures deteriorate the welfare of animals and reduce economic benefits (Frimpong *et al.*, 2012).
- They should be as comfortable as possible for the animals (Broom, 2005).

Other conditions such as starvation, dehydration, injury, suffocation, heat or cold stress, overcrowding, death and many more do prevail in transportation (Warriss, 2000).

2.8 Marketing of animals at the slaughterhouses

In the developed countries where abattoir systems are given attention, slaughter stocks are acquired mainly from farms. These farms feed the abattoirs with the type of animals they slaughter for the public. Therefore, it is a link between butchers and farm owners for regular supply of animals to the abattoirs. However in Ghana, where abattoir systems are at the infant stage, butchers in the slaughterhouses either acquire their slaughter stock from farmers based in the rural areas, cattle markets or from individuals who bring their animals to the slaughterhouse for sale. However some of the slaughterhouses are attached to cattle markets where cattle are brought for sale. At the cattle markets are kraals which are used to house the animals while they are being sold (Frimpong *et al.*, 2012). Animals in such markets are owned by individuals commonly referred to as 'landlords'. These individuals supply the animals to the butchers to slaughter and pay later, which is when the butchers do not have cash at hand. It is also seen as a common practice where butchers procure animals from cattle owners for slaughter and pay later after sales.

2.9 Lairage

A Lairage is a place where livestock are kept temporarily prior to slaughter (Critical Design, Operational and Equipment Guidelines for Licensed Abattoirs, 2012). It serves as a collection point for different animals just before slaughter. The lairage is used to provide animals with some amount of recovery from stress endured during transport. According to a report by Cross *et al.* (2007), health risks associated with meat

consumption may vary depending on the animal the meat is derived from as well as rearing, processing and preparation methods. Ante-mortem inspection should be carried out during lairaging to ensure that unhealthy animals are taken out of the stock. This will give way for sick animals to be identified and isolated for treatment. Again animals that are in their late pregnancy will be taken out and given special care until they are due for parturition. Generally, the lairage should be sized to hold the expected daily kill. It should have sufficient accommodation for the number of animals intended to be held (Shimshony and Chaudry, 2005). The lairage is a specific area inside the premises of a slaughterhouse where animals are conveyed for rest. Rest is an important factor because when animals are stressed, carcasses of lower quality result from slaughter. There should be sufficient space for the animals to lie down to enhance rest and a good supply of portable water for drinking purposes. This is supported by the findings of Jensen *et al.* (2005) who expressed that cattle show a strong motivation to rest in a lying position. The lairage must be well littered and ventilated to promote the well-being of animals. In some special cases a greater capacity may be required although the holding of stock at the slaughterhouse for an extended period before slaughter should not be permitted. Lairage time should not exceed the stipulated time periods for animal species. This is supported by Warriss (2003) who reported that lairage can act as a reservoir of infection by pathogenic bacteria and that longer holding times increase the risk of carcass contamination. For example, the normal lairage time for pigs should be between 2-3hours but half an hour if high temperature (≥35^{o}C) and humidity (>85%) are experienced. Lairage areas for each specific abattoir should therefore be assessed relative to expected throughput.

A Lairage should be constructed and maintained so as to provide protection from unfavourable climatic conditions, using strong and resistant materials such as concrete and metal that have been treated to prevent corrosion. There should be no sharp edges or protuberances that may injure the animals. The floor should be well drained and not slippery; they should not cause injury to the feet of the animals. Where necessary floors should be insulated or covered with appropriate bedding. Drainage grids should be placed at the sides of pens and passageways and not where animals would have to cross them. The lairage should be provided with adequate lightening, but care should be taken to avoid harsh lights and shadows, which frighten the animals or affect their movement. Lairages should be well ventilated and the air flow should be arranged so that odours and draughts do not adversely affect the health and welfare of the animals. Care should be taken to protect the animals from potentially disturbing noise, for example by avoiding the use of noisy hydraulic or pneumatic equipment and muffling noisy metal equipment by the use of suitable padding or by minimizing the transmission of such noise to the areas where animals are held and slaughtered. Where animals are kept in outdoor lairage without natural shelter or shade, they should be protected from the effects of adverse weather conditions (Shimshony and Chaundry, 2005). In localities where animals particularly cattle are normally tethered, a larger area without dividing fences may be preferred to allow tethering rather than penning of animals.

2.10 Isolation Block

In a standard slaughterhouse, a unit is provided for hosting animals suspected of harbouring diseases or illness as well as injured animals. These animals are mostly

identified during ante-mortem inspection in the lairage. The reasons for establishing this block is to:

- Prevent animals with infectious diseases from infecting healthy animals whiles in the lairage.
- Prevent diseased- animals from the meat chain.
- Isolate and treat diseased-animals before they are passed as fit for slaughter.

2.11 Laboratories

In an established slaughterhouse, the presence of a laboratory is very paramount. A well equipped laboratory should be made available in the slaughterhouse for analysis of samples such as meat, blood, body fluids, water and anything suspected of harbouring pathogenic microorganisms. In slaughterhouses where they follow strictly the Hazard Analysis Critical Control Point system of operation to produce wholesome meat, samples of meat suspected of contamination are taken to the laboratory for analysis. Reports are sent to the appropriate authorities to ensure that appropriate measures are taken to prevent sending out contaminated or unwholesome meat to the public. Hazard Analysis Critical Control Points (HACCP) - is a system primarily used in meat plants to ensure food safety. By adopting the system to make regular measurements at Critical Control Points (CCPs) in the process, various critical operations, which are carried out by workers handling and slaughtering livestock, can be monitored to ensure that it is done correctly, leading to steady improvements in welfare and operational quality (Chambers and Grandin, 2001).

2.12 Restraining slaughter stock

Ideally, before animals are stunned or bled it is necessary to ensure that they are properly restrained. This is to ensure stability of the animal so that the stunning operation can be carried out accurately and properly (Chambers and Grandin, 2001). Restraining gives a safety assurance to the personnel doing the stunning and the bleeding as well. However in northern Ghana, animals are normally restrained by tying up their limbs with ropes. Small ruminants such as sheep and goat are sometimes not tied by rope but are pressed down by slaughterers prior to sticking. Their limbs are held by one person whiles the slaughterer do the bleeding. This method disregards completely the welfare of the animal. Different types of restraints are appropriate for different species (Chambers and Grandin, 2001).

2.12.1 Restraining cattle

In modern or standard slaughterhouses where the safety of both workers and animals are taken into consideration, stunning boxes will be ideal for restraining larger animals like cattle and buffalos to prevent accidents during slaughtering. The size of the box should be just wide enough to prevent the animal from turning around during the stunning process (Chambers and Grandin, 2001). The floor of the box should be non-slippery. Restraining tamed cattle outside the stunning box by securing the head in a halter and then pulling the rope through a metal ring in a concrete floor is effective (Chambers and Grandin, 2001). It is recommended that the operator should be positioned behind protective steel bars. Nevertheless restraining cattle in northern Ghana seems tedious due to the way it is done. The commonest means of restraining cattle is by twisting the neck of the animal with the

aid of its horns whiles the tail is pulled side-ways by someone until it is finally brought down. The next is by tying up the limbs together with the neck closer to the head. This makes the animal restless thereby compromising on its welfare. The animal is finally bled by the slaughterer while the animal lies on one side.

2.12.2 Restraining sheep and goats

A properly constructed metal stunning box is appropriate (Chambers and Grandin, 2001). However, they can be restrained manually quite satisfactorily as this is a common practice in northern Ghana where this study took place. They are also sometimes tied by the limbs prior to sticking. Generally, two men are enough for a goat or a sheep restrained.

2.12.3 Restraining pigs

A stunning box is suitable for pigs. Putting a few pigs in a small room is suitable but only for electrical (Chambers and Grandin, 2001). However restraining pigs in northern Ghana is something that has to be reconsidered. Based on the observations I have made on a pig restraint, the pig is tied to a structure and is beaten with sticks or clubs until it becomes unconscious before it is slaughtered. The reason given for beating them before slaughter is to convert subcutaneous fat into meat before it is slaughtered. Considering how gregarious and slippery pigs are, on no account should they be given a manual restrain.

2.12.4 Restraining poultry

Chicken are shackled by their legs onto a conveyor line. This must be done gently to avoid injury and stress. In a small slaughterhouse, birds can be placed headfirst in cones (Chambers and Grandin, 2001). Nonetheless, most of the slaughterhouses in northern Ghana are not into commercial poultry slaughter like it is in the developed world. As

such restraining poultry is normally done manually by one or two people. With the two people, one holds the chicken firm with the limbs and wings together in one hand preferably the left and the right hand holding the neck whiles the slaughterer holds the head with the left hand and the knife in the right hand. Also, with the one man slaughter, the person brings the limbs and wings together and pressed it down with one leg preferably the right leg and holds the head of the bird with the left hand and stick with the knife in the right hand.

2.13 Common methods for stunning

It is desirable to render an animal unconscious before it is slaughtered in order to eliminate pain, discomfort and stress from the procedure (Chambers and Grandin, 2001). Stunning refers to the process of rendering animals immobile or unconscious with a blow on the forehead using a club or a gun design for its purpose. The stunning process is to prevent the animal from experiencing pain prior to slaughter. There are generally three main methods of stunning animals. Whatever the stunning method may be, the animal should be rendered unconscious long enough so that bleeding results in enough loss of blood to cause death from lack of oxygen to the brain (cerebral anoxia) (Chambers and Grandin, 2001). The methods are: Electrical stunning method, Gas (CO_2) stunning methods and Mechanical or percussion stunning method. The end result of each method is to render the animal unconscious.

1. Mechanical stunning method: this method involves firing a bolt through the skull of the animal using a pneumatic device or pistol. Mechanical stunning is the most commonly used method of stunning of cattle and horses. Mechanical stunning types: Captive Bolt Pistol, Concussion stunning and free bullet.

- Captive Bolt Pistol (CBP): This method works on the principle of a gun and fires a blank cartridge and it propels a short bolt (metal rod) from the barrel. The bolt penetrates the skull bone and produces concussion by damaging the brain or causing bruising of the brain. There are two variations of the gun. One has a handle and trigger while the other one comprises a hand-held barrel which is tapped against the skull, which sets of cartridge explosion. This method is extensively used for all agrarian animals. Gun powder (cartridge), compressed air and spring under tension, propels the bolt through the skull of animals. Examples of captive bolt pistols and guns: Accles and Shelvoke
- Concussion stunning: this method involves the application of a severe blow to the skull to cause immediate unconsciousness. It is not easy to ensure an effective blow to the brain in one fast blow. If not applied accurately and with sufficient force, it will cause extreme distress and suffering causing a welfare issue. This method is commonly used for cattle, sheep and calves. Another method which consisted of knocking or striking a hammer on the head of the animal is now banned with regards to inhumane practices in some countries (Nigel, 2002).
- Gunshot: In circumstances where animals such as cattle, buffalo, deer and wild pigs are difficult to be handled in the normal way, such as when they cannot be loaded on the farm or led into the stunning restraint, gunshot with a free, soft-nosed bullet is effective. A 22-calibre bullet is sufficient for most animals (Chambers and Grandin, 2001). Shooting with a free bullet can be hazardous to operators. If the animal is to be slaughtered on a farm, it should be accurately shot while standing or lying on soft ground to prevent the bullet from ricocheting.

2. Electrical Stunning: To induce instantaneous insensitivity, electrical stunning must induce an epileptic or electroplectic state by passing an electrical current through the animals' brain (Chambers and Grandin, 2001). This state should last for long enough for bleeding to be carried out so that the animal dies from cerebral anoxia. A low voltage alternating electric current is applied by means of two electrodes, which are placed on either side of the brain using tongs. Since the brain of animals is small, the electrodes should be accurately and firmly placed high up on the sides of the head in sheep, goats, pigs and ostriches (Chambers and Grandin, 2001). Passage of high electrical current across neural membranes disrupts the normal electrophysiological state and causes profound changes in the electroencephalogram (EEG). In general, this results in charges which persist after the stunning current has been removed, (epileptiform activity) during which the animal is unconscious.

a. Head-Only Stunning: Generally cattle, sheep and pigs are all stunned by the use of this method. With this technique the tongs are placed across the head and cardiac arrest where a current is passed through both the head and heart. An electric current is passed through the brain and this leads to the temporary loss of consciousness (Daly *et al.*, 1986). Head only stunning is reversible and the pig will return to sensitivity unless bled quickly. Cardiac arrest stunning will kill most of the pigs by stopping the heart. For pigs, the amperage that is required to induce epilepsy is 1.25amps (Hoenderken, 1983). There also must be sufficient voltage to deliver the current. The recommended minimum voltage is 250 volts (Troeger and Woltensdorf, 1989).

b) Head to body stunning: Head to body electrical stunning results in cardiac arrest in all species where sufficient current is applied using a low frequency (50 Hz) waveform.

Head-to-body application results in quality problems due to direct muscle stimulation. The intense contractions produced can result in broken bones and muscle hemorrhages (Warriss, 2000).

3. Carbon dioxide (Co_2) stunning: carbon dioxide has been reported to be "humane" to livestock especially pigs. With electric stunning the pigs are normally stuck in traps which are causing much stress. This is the reason for a better meat quality by using CO_2 as less stress means less muscular bleeding, less flesh bone fracture and less PSE meat. However there have been welfare concerns about the humaneness of carbon dioxide stunning because the gas is said to be irritating to the respiratory tract when inhaled (Gregory, 2005).

2.14 Slaughtering and Bleeding

Bleeding is the part of slaughtering process where the main blood vessels of the neck are severed in order to allow blood to drain from the carcass, resulting in the death of the animal from cerebral anoxia (Chambers and Grandin, 2001). To effect bleeding the animal hind legs are hoisted to a convenient height with the head facing downwards. This is done to make sticking (throat slitting) easy and convenient. The bleeding operation is done by inserting a knife through the neck behind the jaw bone and below the first neck bone. The aim is to sever the carotid artery and jugular vein to allow the blood to drain out with ease. The exsanguination process should be as fast and complete as possible due to hygienic norms since insufficient bleeding and slow death could result in blood clotting in the deep tissues and this might be hazardous in the later stages of slaughtering. Blood is an ideal medium for bacterial growth and as such there should be minimal time

between stunning and bleeding to reduce possible contamination. Blood clotting in the tissues will also affect the meat quality. This is supported by the work of Chambers and Grandin (2001) who stated that raw meat quality is severely affected by the stress conditions during slaughtering process and the slaughtering methods. Elevation bleeding is more hygienic and is preferred to other alternatives. This is because hanging carcasses by hooking the hind legs puts many muscles into tension and stretches the sarcomere lengths which may produce meats that are more tender (Warriss, 2000). It is important to note that during the slaughtering process, animals should not be slaughtered in the sight of other stock. Animals seeing their own slaughtered and the pool of blood may put fear in them. This makes them struggle even more with the slaughterers especially if it is cattle or other bigger animals. Ekesbo (2011) had it that if cattle are nervous or frightened they pass-out their droppings more often and usually more liquid faeces. Gruber *et al.* (2010) also reported interaction between blood hormones and behaviours of cattle. Through their struggle, injuries can result both on the side of the animal and the slaughterers. The struggle the animal undergoes can affect its meat quality when slaughtered.

2.15 Religious or ritual slaughter (Halal and Kosher)

In Ghana, less attention is given to animal stunning as compared with slaughterhouses in the developed world. According to Adzitey *et al.* (2011) butchers in Ghana do not have much knowledge about the stunning of animals and the benefits it has on the quality and shelf life of meat. Muslims believe that stunning animals before slaughter is against their religious doctrines. They perceive stunning as a practice that can easily kill an animal

without the operator's knowledge and since they do not consume animals which is not bled according to their practice, they consider such carcasses as unfit for their consumption. With ritual or religious slaughter, stunning is not allowed and the animal is bled directly using a sharp knife to cut the throat and sever the main blood vessels. This results in sudden and massive loss of blood with loss of unconsciousness and death. Most developed and many developing countries have legislation that requires pre-slaughter stunning, with the exception of authorized ritual slaughter like kosher or Halal (Chambers and Grandin, 2001). Whilst stunning has been embraced by the animal welfare activist as a way of promoting animal welfare, some religious bodies such as Muslims and Jews disagree with stunning on religious grounds. Their religion forbids consumption of meat which was not killed directly by bleeding. However, many Muslim authorities accept some forms of pre-slaughter stunning (Chambers and Grandin, 2001). Many Muslims authorities permit electric stunning of cattle, sheep and poultry, whose meat is destined for Muslim communities because the animals subjected to this stunning method, would recover if no bleeding was carried out. Similarly, Muslim minorities in countries with stringent animal welfare regulations are allowed to use Halal slaughter methods, but in combination with electrical stunning (Chambers and Grandin, 2001). Any kind of pre-stunning for livestock to be slaughtered according to the Jewish Kosher method has not yet been accepted (Chambers and Grandin, 2001).

2.16 Animal slaughter processes

In the developed world, the slaughterhouse is recognized as a meat producing venture and all slaughtering activities are carried out in the unit and the meat distributed to various

retail centres or sent to the animal owner if it is brought to be slaughtered by an individual. In most developed nations, abattoirs have aided in the detection and eradication of several diseases besides their main purpose of meat inspection (Kaneene *et al.*, 2006). However in northern Ghana, slaughterhouses are cited in the cities and communities but are not patronized by most people especially the rich and educated because of the filth engulf by those places. In developing nations like Ghana, abattoirs are not maximally utilized and even the meat passed for human consumption in many instances is not adequately monitored (Shima *et al.,* 2015). As a result, they prefer killing animals in the house for meat than buying meat produced from the slaughterhouses. Also, they turn to produce meat from diseased and injured animals due to the lack of knowledge on animal welfare. Proper slaughterhouse procedures involve examination of live animals before slaughter (ante-mortem examination), stunning, sticking, skinning or singeing, evisceration, carcass splitting, carcass inspection (post-mortem inspection), chilling, cold van transportation and waste disposal. All these activities are crucial to the delivery of wholesome meat and surveillance of animal diseases especially those of public health importance (Nwanta *et al.,* 2008). Hygiene should be observed at all stages of the production line until the meat gets to the final consumer. This requires that the slaughterhouse should be designed in such a way that each stage in the production line does not promote meat contamination. Nevertheless, majority of slaughterers and butchers in northern Ghana do not follow these procedures in producing meat in the slaughterhouses. They slaughter animals by struggling with them especially at the point of casting and restraint. This could be attributed to the fact that majority of the butchers are illiterates and do not have any formal education that can help them understand the

importance of these procedures and why they should apply them in their butchering business. It is important that personnel involved in meat production be trained on animal handling and meat production in northern Ghana. Slaughtering technology is becoming more important as it has a large influence on meat quality (Swatland, 2000). There are principles involved in a slaughtering process. The sub-processes are divided into "dirty" and "clean" operations. The dirty operations include: lairage, stunning, slaughtering and bleeding. The clean operations are: evisceration, chilling/ hanging, cutting/deboning and freezing/ delivery.

The processing principles are shown in the flow-diagram in Figure 1.

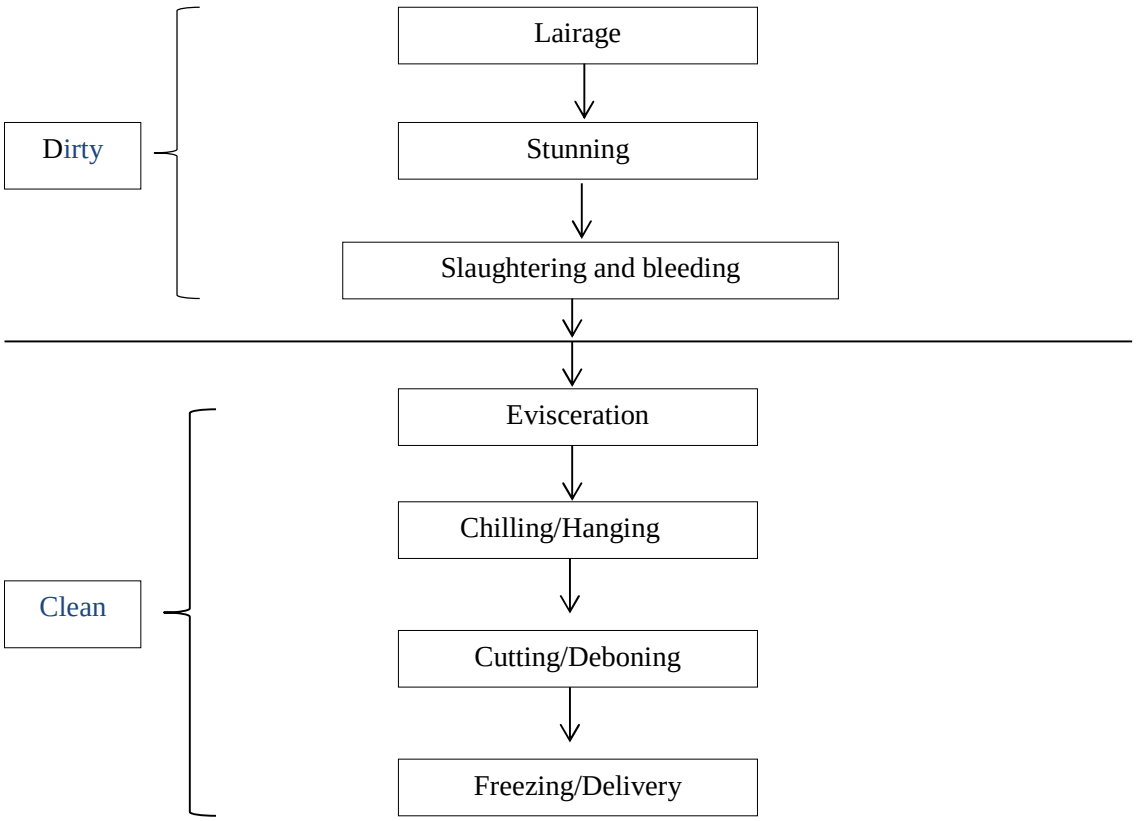

Figure 1: A flow chart showing the various slaughter procedures

2.16.1 Skinning/flaying

It is advisable to hoist the carcass before skinning to prevent the meat from touching the floor. Some slaughterhouses hoist their carcasses before skinning them while some do not (Evans, 2010).

Skinning is the process of carefully removing the skin of animals. It can be done manually or by the use of a machine. Although the process may vary according to the animal (cattle, sheep or goat), the process follows a similar procedure. Cutting of the skin is made around the hind leg with the aim of exposing and loosening the tendon of the animal's lower leg joint to be used for hanging the carcass. After this the entire skin is removed gradually and with caution if manual to prevent puncturing the skin and living it with holes. Skinning can also be done using an automated machine. After the skinning process the body is prepared for evisceration (Small and Buncic, 2009). This process is usually meant for cattle, goat, deer and sheep.

2.16.2 Scalding/dehairing

Normally carcasses of small ruminant are prepared by passing it through the scalding procedure. The carcasses of animals such as pigs, goats, lamb and poultry are prepared through scalding by passing the carcass through hot water or steam. Scalding animals such as cattle, goat and sheep is not common in Ghana. The reason attached to this is that, their hides or skin is served as raw materials for the leather industries in the manufacturing of items such as belts, shoes, hats and rain coats. However, poultry carcasses are normally processed through scalding. This is a common practice even in

individual homes. Scalding procedures differs from animal to animal but it is commonly applied on pigs and poultry (Chambers and Grandin, 2001). It can be done by either pouring hot water onto the carcass or submerging it in a container filled with hot water. The simplest equipment for scalding consists of a tank into which the pig is lowered by a hoist. The water is heated by oil, gas, electricity or open steam-pipe. Locally, the water can also be heated by firewood or any cheap source of fuel (Sunu, 2013). To check the effectiveness of the scald, rub the skin with the thumb to see if hair comes away easily. To reduce contamination, scalding water should be changed frequently. Pigs should be as clean as possible at sticking and bleeding should be fully completed before immersion. During the scalding period, care must be taken with regard to the right temperature of boiling water to be use for the process. Too much hot water should not be used for the process otherwise the carcass is likely to be cooked and too low a temperature must not also be used less the hair follicle will not loosen to eject the hair. The right temperature of water for scalding should be 60-62^{o}C.

2.16.3 Singeing

Singeing is the process of removing the hair or feathers of animals with naked flame. The singeing process is done by passing the carcass through naked flames commonly after scalding. The most common singed animals in Ghana include pig, goat, sheep, poultry and cattle. The reason for singeing after scalding is to burn off left over hairs on the skin of the carcass after the scalding procedure. Singeing is done because it removes hairs off the animal, reduces the number of adhering microorganisms, shrinks and sets the skin and leaves an attractive clean appearance. It can be done with a hand-held gas torch or automated systems can be used to transport the slaughtered animals into a furnace and

give it ample time for an effective singe (Sunu, 2013). Black deposits on hides and burnt hairs are scrapped off with a knife or wire mesh and the carcass is washed thoroughly with clean water prior to evisceration. Traditionally, singeing is done in open fire fuelled with firewood, but local butchers have resorted to the use of scrap tyres as alternative source of fuel to singe slaughtered livestock due to the relative scarcity of firewood in recent times (Sunu, 2013). However local butchers prefer the practice, though unconventional and potentially dangerous, because fire from the scrap tyres is able to selectively burn off the animal fur without cracking the hide (Obiri-Danso *et al.,* 2008). The common sources of fuel for carcass singeing in Ghana include fire wood, liquefied petroleum gas (LPG), old car tyres and recently biogas. In northern Ghana which is the study area of this research, fire wood and old car tyres are reported to be the fuel for carcass singeing. This agrees with the findings of Sunu (2013) who attest that in Ghana singeing practices predominantly used in the processing of slaughtered livestock include, the use of fire fuelled by scrap tyres or LPG gas to remove animal fur. However she stated that singeing with scrap tyres poses a health challenge as an environmental hazard (Sunu, 2013). Tyre-singeing leads to the accumulation of heavy metals in meat which poses health risks when eaten. In a study carried out in Ghana Obiri-Danso *et al.*, (2008) reported that, the levels of heavy metals in the singed animal hides were generally high compared to the levels in some other meat products in India and the Slovak Republic (Santhi *et al*., 2008). Another report by Essumang *et al.* (2007) attributed heavy metals in cattle hides (wele) in Ghana to tyre-singed treatments and reported elevated levels for iron, zinc, chromium and nickel respectively in singed hides processed with vehicle worn-out tyres. Hauser *et al.* (2009) reported that high doses of cadmium can lead to

kidney failure, damage to testicles and liver. Lenntech (2012) also indicated that an uptake of too large quantities of nickel leads to higher chances of development of lung, nose, larynx and prostate cancer, lung embolism, respiratory failure, birth defects, asthma, chronic bronchitis and heart disorders.

2.16.4 Carcass washing

After bleeding and singeing, the carcass must be wash thoroughly with clean water. Preferably the carcass should be washed under running water to remove possible soiling, hair and other dirt that might be found on the skin or flesh of the carcass. In slaughterhouses where car tyres and firewood are used for carcass dressing, the carcass turns black and smoky due to the burns and smoke of the fuel used. Essumang *et al* .(2007) reported that they were heavy metals such as zinc, chromium and nickel in cattle hides (wele) due to the use of old car tyres in singeing carcasses of animals.

2.16.5 Evisceration

Evisceration is a process which consists of the removal of the internal organs of an animal through the abdominal and thoracic regions. During evisceration special care must be taken to avoid damaging the intestines in order not to soil the meat with the content of the intestines. The internal organs are also known as offal and it is categorized into two:

- Red offal such as the heart, liver and lungs (pluck).
- Grey offal such as the stomach or intestine (paunch).

To avoid contamination of the carcass through accidental punctures of the intestines and stomach, it is important that the carcass is placed in the hanging position.

The body cavity is severed and the intestinal mass and the stomach (the paunch) are pushed slightly out. The liver is held out carefully during this process. This is to prevent

an accidental release of the bile content onto the carcass and as such spoil the taste of the meat. The last stage in evisceration is the removal of the contents from the chest cavity. The diaphragm is cut open giving way for the removal of the lungs aided by pulling the wind-pipe. Edible organs must be handled in a hygienic way by putting or storing it in separate clean containers. Waste must be removed rapidly from the floor in the evisceration room or area. Sterilizers must also be made available for hand tools in the evisceration area.

2.17 Condemned products

The study of carcass condemnation could be used as a control tool to verify the emergence, evolution and control of many diseases. As such it is important that every slaughter facility have a condemned unit where rejected carcass can be put for immediate destruction. In a ten year study done in Ahwaz, Iran, among a total of 3583417 slaughtered animals including sheep, goats and cattle, 4.24% of livers and 6.37% of lungs were condemned (Ahmadi and Meshkehkar, 2010). Carcasses or meat that is infested beyond human consumption is declared unfit by an authorized officer or meat inspector. The said meat is separated into the condemned room and treated with chemicals to hasten its decay and also to prevent people from consuming it. It is also buried to prevent access by animals such as dogs and wild birds. From 2005-2007, 0.02% of cattle carcasses, in Iran, were condemned due to bovine cysticercosis (Jahed Khaniki *et al.,* 2010). In another survey carried out in DebreZeit, Ethiopia, the condemnation rate of liver, lung, heart, kidneys, brain and carcass among 1152 slaughtered sheep were 58.5%, 44.5%, 8.6%, 6.5%, 4.3% and 6.7%, respectively (Jibat *et al.,* 2008). The literature available regarding

the causes of carcass condemnations in pigs is scarce (Martinez *et al.*, 2007) and research on carcass condemnation has focused on other species (Ansari-Lari and Rezagholi 2007; Regassa *et al.*, 2013). Reports on the spatial condemnation of swine carcasses and its economic implications, condemnation of growth-retarded pigs and the utilization of records of pig condemnations as a spatial disease surveillance method have been published (Martinez *et al.*, 2007; Thomas-Bachli *et al.*, 2012; 2014). Meat is also condemned from human consumption because of aesthetic values caused by diseases and mechanical damage during slaughtering operations. Variations in the causes and prevalence of carcass condemnations reported in different studies may be associated with the geographical area, climatologically conditions, farm management and herd health status (Martinez *et al*., 2007).

2.18 Chilling/freezing

Chilling is employed at slaughterhouses immediately after slaughtering and during transport and storage. Chilling is critical for meat hygiene, safety, shelf life, appearance and nutritional quality (Zhou *et al.*, 2010). Chilling is employed by two methods: immersion chilling, in which the product is fully immersed in chilled water (0-4^{o}C) and air-chilling in which the carcasses are misted with water in a room with circulating chilled air (Carroll and Alvado, 2008). Carcass surface temperature is reduced at faster rate by air chilling which improves carcass drying and minimizes microbial spoilage (Ockerman and Basu, 2004). Another concept that can help reduce storage and transport cost is super chilling. Super chilling is a different concept than refrigeration and freezing and it has the potential to reduce storage and transport cost (Reynolds, 2007). Super-chilling refers to the temperature zone below its initial freezing point (1-2^{o}C) but where

ice crystals are not generated. In this process, instead of adding external ice to the product, part of the internal water is frozen and works as a refrigeration reservoir, ensuring its refrigeration during distribution and transportation (Bahuaud *et al.*, 2008). However, most slaughterhouses lack preservation facilities such as cold rooms and refrigerators for carcass/ meat preservation. This is backed by Adeyemo (2002) and Lawan *et al*. (2013) who reported that most slaughterhouses lack slaughtering and processing facilities, inadequate clean water supplies and refrigeration systems. Carcasses not meant for early or fresh distribution should be hanged in the cold room or in the deep freezer if to be frozen. The main objective is to retard bacterial growth and extend the shelf-life of the meat product. When chilling is carried out, there must be sufficient chilling capacity and space to ensure sufficient chilling. If carcass is frozen, the freezing capacity must be sufficient to ensure adequate freezing. Freezing is an excellent method of keeping the original characteristics of fresh meat and meat products. Meat contains about 50-75% by weight water. Depending on the species and the process of freezing most of the water is converted into ice (Heinz and Hautzinger, 2007).

2.19 Cutting and deboning

Deboning simply refers to the process of removal of bones from a carcass. Meat is either sold bone-in or boneless depending on consumer preference or the intended use for it. After the carcass is cut into the required sizes, customers who prefer boneless or bone-in placed a request to be served. The carcasses must be cut preferably hanging or on surfaces such as tables, cutting planks and chopping blocks which are regularly cleaned. The deboning process must be done with absolute care to prevent crushing and leaving

pieces of bones in the muscles. Protective wears especially goggles must be worn to prevent particles of bones from falling into the eyes. Premises where meat is cut need to be equipped to meet the operational requirements for the hygienic cutting and boning of meat.

2.20 Food packaging

Food packaging is defined as a co-ordinated system of preparing food for transport, distribution, storage, retailing and end-use to satisfy the ultimate consumer with optimal cost (Coles *et al.,* 2003). The first ever branded package was introduced in England in 1746 by one Dr. Robert James who packaged his "fever-powder" in a box for retailing (Ariev, 2007). Other people followed suit by packaging using different materials for different food products. Few years back most food vendors and butchers in Ghana and for that matter Tamale used simple natural materials such as broad leaves of certain tree species and old newspapers for packaging meat and other food products. Kirwa (2003) reported that the use of paper and paperboards for food packaging dates back to the 17th century with accelerated usage in the later part of the 19th century. However with the advancement of technology and also for health reasons, this traditional practice was almost abandoned and new packaging ideas adopted. But in recent times, exclusively manufactured synthetic plastic materials such as paper or synthetic films are used for meat packaging. Jan *et al*. (2005) reported that the most commonly used polymers for food packaging are: low-density polyethylene (PE-LD), high-density polyethylene (PE-HD), polypropylene (PP) and polyamide. Also, plain paper is not used to protect foods for long periods of time because it has poor barrier properties and is not heat saleable.

The World Packaging Organization estimated that more than 25% of food is wasted because of poor packaging (WPO, 2009). Based on this, it is important that food packaging be promoted to reduce food wastage and prolong shelf-life.

Purpose of meat packaging (Shin and Seike, 2014) include;

- Protect microbiological and physio-chemical against impacts that alter meat composition and quality in order to prolong its shelf-life.
- Protect meat during processing, storage and distribution. This view was shared by Smith (2003) as he reported that a pack must protect its content during storage, transport and usage.
- Serve as a container for meat.
- Provide consumer easy handling, convenience and conformality.

Importance of meat packaging (Shin and Seike, 2014) include;

- Enhance the shelf-life of meat and meat products.
- Reduce evaporative weight loss.
- Improve water holding capacity of meat.
- Inhibit oxidation reaction which leads to colour distortions.

2.21 Carcass and meat delivery

After the slaughtering processes, the carcass should be weighed and labelled for identification and made ready for distribution to the various meat shops in the local market. Ideally, the carcass should be conveyed preferably by a cold van to the market centres. The truck or van for transporting meat should be considered as an extension of the cold room or refrigerator for meat storage. The temperature of meat before loading

and during transport should be or near 0°C. The aim is to maintain the meat temperature from the refrigerator or cold room till the meat is delivered. The appropriate truck or van is an insulated one where in the absence of a refrigerating system; dry ice can be added to help keep the carcass temperature. Un-insulated vans or trucks should not be considered as suitable transport for meat as this will cause early deterioration of the meat due to temperature differences. Vehicles for transporting meat that are not properly cleaned or maintained may also give rise to chemical hazards (Functional Requirement Specification, 2008). Loading and unloading should be done by personnel who observe personal hygiene. The meat carrying compartment of meat transport vehicle, the equipment to be used in the meat carrying compartment and the equipment to be used for the loading of meat and meat products should not be a source of contamination of meat and meat products (Ernest, 2015). They must be cleaned with portable water and disinfected before and after commencement of work each day (Australia Food Regulation Standing Committee, 2007). In northern Ghana and for that matter Tamale, meat delivery/ transportation need to be looked into seriously. In these areas, carcass is commonly transported to the local market and to various points of sale in open motorised tricycles commonly referred to as “motor-king” and pick-ups. At the time of this study, a van was used to convey meat to the market centres, although it was not insulated nor had any cold system. Fearon *et al.* (2014) attested that “there is only one old, wretched meat van used to transport meat to the market” from the Tamale abattoir. They added that majority (93%) of the butchers convey their meat on bicycles, motorbikes and motorized tricycles, popularly known as motor king (Fearon *et al.*, 2014). This also agrees with the findings of Ernest (2015) who mentioned that the popular means of transporting carcass

from the abattoir to sale points in Birim north district is by the use of taxi, mini buses such as Hyundai (H100) and tricycles. Adzitey *et al.* (2011) and Abuska (2006) reported that the popular means of transporting raw beef carcass from the abattoir to sale points in the Bawku Municipality and Garu-Tempane district respectively are through motor bikes, bicycles, push trucks, basins on butcher's head and on the hands and shoulders of butchers.

2.22 Precautions that have to be maintained during slaughtering

a) Disinfection on entering the premises

Any time an authorized officer or member of staff is to enter the slaughterhouse; he or she should undergo a process of disinfection by dipping his or her boots in a footbath. The footbath is a basin situated at each entrance of the slaughter line serving as a bio-security measure to prevent disease transfer in the slaughterhouse. This is to prevent people from transferring pathogenic microorganisms into the slaughterhouses through their boots.

b) Bleeding and exsanguinations

The knife for sticking should be about 15cm long and be sharpened on both ends. The knife used for slaughter purpose must be clean and sharp (FAO, 2005). The knife used to slaughter each animal should be cleaned and rinsed in hot water as a means of disinfection. It is known that a contaminated knife can pass on bacteria into the animal tissues during the initial stages of bleeding, that is, when the heart is still beating (Reij *et al.*, 2003).

c) Skinning

The knife for skinning cattle should be reasonably long and curved. The curvature is to prevent the knife from puncturing the skin and make skinning relatively faster and easier. The skinning knife and the use of bare hands can similarly hosts contaminating organisms on the surface of the carcass.

As such washing of the hands is a must after the passage of each carcass to avoid contamination of same (Reij *et al.*, 2003).

d) Evisceration

Extreme care should be taken not to puncture the intestines. The content of the intestines contain lots of infectious microorganisms and is a possible source of contamination. Slaughterers and butchers should follow the procedure of tying up the rectum and the severed end of the oesophagus to prevent its content from spilling. The intestines and the stomach should be removed first, followed by the pluck (heart, liver, and lungs) of the slaughtered animal. The pluck should be hung on a hook while the paunch (stomach) should be dropped in a paunch container. As a matter of hygiene, the stomach and intestines should not be processed while carcass dressing is in progress as any minor splash from same can easily cause contamination of the meat.

e) Washing

It is the process by which the carcasses undergo washing with clean portable water. The primary reason of carcass washing is to remove visible soiling and blood stains and also to improve appearance after chilling. Simply washing with water is no substitute for good hygienic practices. Carcass spraying will remove visible dirt and blood stains. Soiled carcasses should be sprayed immediately after dressing before the soiling material dries. This will minimize time for bacterial growth. In the process of removing stains from the

skin surface, particular attention must be paid to the sticking wound and the pelvic region.

f) Offal handling

The offal (stomach and intestines) are the organs from the carcass which contain the greatest load of infectious microorganisms and for preventive measure must be moved to a separated chamber provided for them. At first they should be emptied of their contents, dried, and then cleansed with water. Hajimohammed *et al.* (2014) stated that inspection of carcass and offal should be carefully done in slaughterhouses to ensure that meat is safe and hygienic.

g) Personnel

The personal hygiene of the workers is a very important factor to consider during the slaughtering operations. The reason is simply that, contamination of food and disease transmission, depend upon the human factor as well as on the tools and mode of operation. Transfer of microorganisms by personnel particularly from hands is of vital importance (Bloomfield, 2003). During handling, bacteria are transferred from contaminated hands of workers to the food and subsequently to other surfaces (Montville *et al*., 2001). None adherence to the use of protective wears during meat processing increase the risk of cross contamination because meat handlers are potential sources of contamination for microorganisms. This is in agreement with reports of the World Health Organization (2004) on cross contamination between food handlers and food products in meat workers that do not use protective materials. This is also supported by Nel *et al.* (2004) who reported that wearing protective clothing give protection to both food products and meat handlers from cross contamination. Therefore food handlers should

wear gloves while handling food and must wash hands regularly with soap and hot water and most especially under running water to reduce the microbiological load on hands (Meat Technology Update, 2010). Forsythe (2000) reported that as much as 10^7 counts of pathogenic microorganisms are present in the fingernails of people handling food due to poor personal hygiene practices. Poor hygiene, particularly the absence of hand washing has been identified as the causative mode of transmission. Proper hand washing and disinfection has been recognized as one of the most effective ways to control the spread of pathogens, especially when considered along with the restriction of sick workers (Montville *et al*., 2002). The hands of meat handlers are heavily loaded with staphylococcus microorganisms due to contact with saliva and other bodily fluids during spitting, coughing and sneezing. Therefore persons with unhygienic habits like spitting, coughing and nose-blowing should be strictly monitored to ensure that they do not contaminate the food they work on. It is important to limit access into the premises during the time of slaughter. All personnel that are allowed access should also be dressed in the appropriate personal protective clothing, example, clean trousers and wearing appropriate waterproof aprons. Boots should be worn with the trousers neatly folded inside. The hallmark is that the workers must strictly abide to a formal code of hygiene.

h) Hand-washing

As stated by the Centres for Disease Control and Prevention: "It is well-documented that one of the most important measures for preventing the spread of pathogens is effective hand washing (Montville *et al*., 2002). Fundamentally the good habit of careful and frequent hand-washing will definitely reduce contamination. Most butchers handle or touch numerous materials before going into the meat production and processing room, as

a result they are easily involved in cross contamination. Also, majority of meat sellers handle meat concurrently with money and also sometimes soiled the meat with their saliva as they speak. Since money is full of microbes, it can contaminate the meat. This is asserted by observations of kumar *et al.* (2009) on the quality of beef produced and sold in parts of Tigrai region of Ethiopia when meat and money are not handled by same hand during sale of meat. Therefore hand-washing facilities with sufficient water supply must always be provided for use by the workers. Maintaining clean hands, wearing clean protective clothing to cover both body and hair and using thoroughly cleaned and regularly sterilized slaughtering knives and equipment are requirements for good hygienic practices and production of high quality meat (Sulley, 2006; Soyiri *et al.*, 2008; Adzitey, 2011). Basically the mess room and the working area are where there should be several hand-washing points. If it is kept away from working places, it is a probability that they will not be used and this can result in contamination of the meat during preparations in the slaughterhouses. Good hygienic practices are extremely important to prevent microbial contamination in meat and other foods in addition to proper handling, cooking and cooling practices (Doyle, 2007).

It is important that members of staff wash their hands regularly, especially;

- before they begin the slaughtering of animals
- after visiting the toilet
- after coming into contact with dirty objects and materials
- after smoking and eating

The staff should understand that the hands are prone to contamination if used for scratching the skin, the hair, clothes and picking the nose (Ofosu-Koranteng, 2010). Such

acts may cause bacteria to be transmitted to the hands and thereafter infect the meat which is handled by the same hands. To reduce possible contamination, disinfectants and antiseptic soaps should be made available in the slaughterhouses for effective hand washing by personnel directly involved with meat.

i) Cleaning Operations

For the purpose of sanitation clean water is usually required for the cleaning of equipment, tools, floors and walls. Such operation normally starts with the removal of solid waste of meat and fat trimmings and pieces of bones from the area. Blood clots and other waste materials on the floor may be dealt with by scrubbing them off the floor. High pressure water cleaning begins from the walls and finally ends with the floors. Hot water hosing under pressure would be ideal for removing sticky waste from corners and drains. For scrubbing of other surfaces such as tables, and tools, the use of hard fibre brushes and detergents is suggested. Liquid detergents are more effective than ordinary soaps, since they dissolve easily in water while absorbing dirt, which is finally removed by flushing. Powdered soap may also be dissolved in water and used in cleaning activities in the slaughterhouses.

2.23 Waste management

Waste is a problem in slaughterhouses more especially in developing countries including Ghana where this study took place. Slaughterhouse waste is a potential reservoir of bacterial, viral, parasitic and prion pathogens capable of infecting both animals and humans. Improper handling and disposal of these wastes may thus lead to contamination of the environment e.g. water and soil and eventually cause disease in animals and people

living close to these areas (Evans, 2015). A quick cost effective and safe disposal method is therefore essential in order to reduce the risk of disease following animal slaughter (Franke-Whittle, 2005). Slaughterhouse wastes constitute the inedible parts of animals derived from the production of meat, as well as blood and other animal by-products. Inedible animal tissues (organs, integument, ligaments, tendons, blood vessels, feathers, bone) can comprise up to 45% or more of the slaughtered animal (Jahed *et al.*, 2010). The remaining fraction, is however, not only fit for disposal but can be sold as pet food to companies known for purchasing large amounts of slaughterhouse waste. These can be used either alone or as a supplement for animal feed (Salminen and Rintala, 2002). Large quantities of waste are produced worldwide, and their disposal poses a serious logistical challenge for meat/poultry processing plants. As a result of such high magnitudes of animal waste, and because of the legal restrictions and rising treatment costs of removal, improper and unsafe disposal of these wastes can occur. Such practices can then also lead to serious environmental problems (Arvanitoyannis and Ladas, 2008). Throughout history, burial and to a less extent, burning have been the most commonly applied methods for the disposal of on-farm mortalities (Gwyther *et al.*, 2011). However, the European Union (EU) Animal By-product Regulation (EC) no. 1774/2002 (Anon, 2002) does not allow these practices to be conducted within the EU and limits the disposal routes to incineration (either on or off-farm), rendering, high temperature/pressure, disposal at maggot farms or through licensed waste collectors (Anon, 2002). The prevention of disposal by burial and burning was founded based on the risk of an incomplete destruction of pathogens from mortalities during these processes, and thus the entering of infective agents into the animal feed chain (Anon, 2002). A junk of the waste

from slaughter plants are in liquid form as a result of carcass washing, floor cleaning and washing of equipment among others. This effluent flows through the guttery to link with water bodies around the surrounding areas. The effluent also contains various levels of microorganisms that pose a health threat to consumers who source water from those water bodies for their choirs. Weobong and Adinyira (2011) attested that, activities of the main abattoir in the Tamale metropolis showed that effluent water from the facility was highly polluted. Residents within the community where the slaughterhouse is located complained of stench from effluent, pollution of their water sources and frequent disease outbreaks among others (Adinyira, 2011). The easiest disposal method is to divert effluents into existing pools, rivers or lakes. These pollutants cause water contamination and affects aquatic life. However, this method cannot be recommended in view of the consequent contamination of water sources for humans, domestic and wild animals. Wrongful discharge of blood and animal faeces into streams may cause oxygen depletion as well as nutrient-over enrichment of the receiving system which could cause increased rate of toxin accumulation (Nwachukwu *et al.*, 2011). Some researchers point out that abattoir activities are responsible for the pollution of surface and underground waters as well as air quality which indirectly affect the health of residents living within the vicinity of abattoirs (Odoemelan and Ajunwa, 2008; Patra *et al.*, 2007).

Studies from Nigeria and Ghana showed that many abattoirs in the respective countries either deposit waste materials in the immediate environs or dispose them off directly into water bodies, some of which serve as sources of water for abattoirs (Adelegan, 2002; Osibanjo and Adie, 2007; Weobong, 2001). Although abattoir waste carries high levels of microorganisms that may be harmful to humans, they are an excellent substrate for

generating biogas (Rabah *et al.*, 2010). For the safe disposal of liquid and solid waste, the following action should be taken:

- Separation of blood
- Screening of solids
- Trapping of grease

a. The blood from slaughtered animals will coagulate into a solid mass, which may block up both open and closed drains. It is therefore recommended that the blood is collected and used for human consumption; stock feed production or fertilizers, if the religious and cultural traditions allow the use of blood.

b. Solids (meat or skin trimmings, hair, pieces of bones, hooves, etc.) must be screened. This may be done by providing the drains with vertical sieves.

c. Effluents from slaughterhouses always contain small amounts of fat (melted fat or small pieces of fatty tissues). Grease traps should be installed in the drains. The fat solidifies, rises to the surface and can be removed regularly (Ockerman and Hansen 2000).

2.24 Diseases associated with unhygienic slaughtering

There are many different ways by which an infectious organism can make its way through the slaughtering process of animals and subsequently cause diseases. The most basic causes include;

1. Infections from the skin/hides of animal soiled with dirt that harbours infectious microorganisms.

2. The water used in cleaning carcasses and other operations during the slaughtering process.
3. Infections from slaughterers through their dresses or body surfaces. Slaughterers who do not use protective wears increase the risk of cross contamination because meat handlers are probable sources of contamination for microorganisms. This agrees with the findings of the World Health Organization (2004) and Muinde and Kuria (2005) on cross contamination between food handlers and food products in meat workers that do not use protective materials.
4. Cross contamination (i.e. from one carcass to another using the same equipments during the slaughtering process by slaughterers).
5. The floor and surfaces of the slaughter plant
6. The means of transport to the market or sale points. As a result of the above mentioned causes, most of the meats produced from the slaughter plants are infested with microbes in one way or the other. This is supported by the findings of Adzitey *et al.* (2010) who conducted a study on the, quality of chevon and mutton sold in three major meat shops in the Tamale metropolis and concluded that samples from all the shops were contaminated with microbes (*Streptococcus spp., Staphylococcus spp*., *Enterococcus spp*., *Salmonella spp*., and *Escherichia coli*).

Genera of bacteria originating from infected food handlers include *Escherichia coli, Staphylococcus aureus, Salmonella spp., Bacillus cereus,* faecal *streptococci* and *Shigella spp*.

2.25 General maintenance of the slaughterhouses

The slaughterhouse needs a constant maintenance to provide the right environment to aid in producing healthy meat and meat products. Constant maintenance of the facility will prolong its existence and keep it in business. All sections of the slaughterhouse must be maintained always especially the slaughter line which is one of the major sources of meat contamination in the facility. Observing a good maintenance culture will help reduce meat contamination and promote the safety and welfare of workers in the facility. The following maintenance procedures must be carried out at least once in a year in the facility:

2.25.1 Maintaining the building of the slaughterhouse

- The entire building especially parts of it that is made of concrete and blocks must be checked thoroughly for cracks or crevices. The walls and floors are structures in the facility that normally develop the cracks and these could serve as hiding places for rodents and pest who find their way into the facility. These cracks should be filled with the appropriate materials to avoid pest and other organisms that use the crevices as their breeding grounds and a threat to meat safety in the slaughterhouse.
- The roofing especially if it is roofed with zinc must be checked periodically to replace those that are corroded and have holes with new ones.
- If the building is ceiled, it should be checked at least once in a year to make sure that the ceiling is not rotten especially if the roof is leaking. Pests such as bats,

rats and wall geckos see the ceiling as the best harbouring place if given the opportunity.

- The doors and windows must be maintained by replacing broken doors and windows. The glasses, wire netting and burglar proof used on these structures must also be checked periodically to replace broken ones with new ones.
- The guttery in the floor of the slaughter hall must always be maintained to ensure that gut materials and meat particles are not left in the crevices to rot and serve as a source of contamination.
- When the paint of the building fades, it must be repainted to boost its appearance again.

2.26 Routine cleaning of the interior and equipment of the slaughterhouse

Ideally, it is important that a slaughterhouse especially the interior part of it be constantly clean. Personnel involved in sanitary activities must always make sure that the facility is clean. The floors must be swept of all debris such as meat trimmings, faecal matter, hooves and horns especially in the slaughter halls. After sweeping the floors, it must be washed thoroughly with detergents and if possible with hot water. This is to ensure that dirt is not left on crevices to give chance to infectious microorganisms to breed and hide. Equipment used for the day must also be given a serious wash with soap or detergents preferably with hot water. Contrary to this, most of the slaughterhouses in northern Ghana are not given such kind of cleaning attention. The interior part of the slaughterhouses, especially slaughter halls are only swept and washed with cold water without detergents and sanitizers. In large slaughterhouses, the slaughter halls (floor and

wall) are not cleaned at the end of the working day and may be left for 2 to 4 weeks or even months while in small ones it may be done daily (Hassanien *et al.,* 2014). As a result, the floors of the slaughter halls are often left with blood stains and faecal matter. The equipment used for the slaughter operations are only rinsed with cold water and without soap or detergents. Therefore to promote cleanliness and sanitation in the slaughterhouse, it is necessary that effective cleaning after daily operations be adopted and enforced.

CHAPTER THREE
MATERIALS AND METHOD

3.1The Study Area

The study was carried out in the three northern regions of Ghana. These regions were: Upper East Region, Upper West Region and Northern Region. According to the 2010 Population and Housing Census (PHC) the total population of northern Ghana was 4,228,116 representing 17.1% (Ghana Statistical Service, 2010). Out of this population, the Northern region (NR) had a total of 2,479,461 people representing 10.1%, Upper east region (UER) had 1,046,545 people representing 4.2% and Upper west region (UWR) with the least population of 702,110 people representing 2.8%. These three regions lie in latitude 8^{o}N, 11^{o}N and longitude 0^{o}E 3^{o}W (Ghana Agricultural Production Survey, 2013). The vegetation of this area consists of grassland sparsely dotted with small drought resistant trees. The study areas experiences one rainfall season annually beginning in March and ending in September. The average temperature is 31^{o}C with a minimum of 28.2^{o}C and a maximum of 34^{o}C (SARI, 2008).

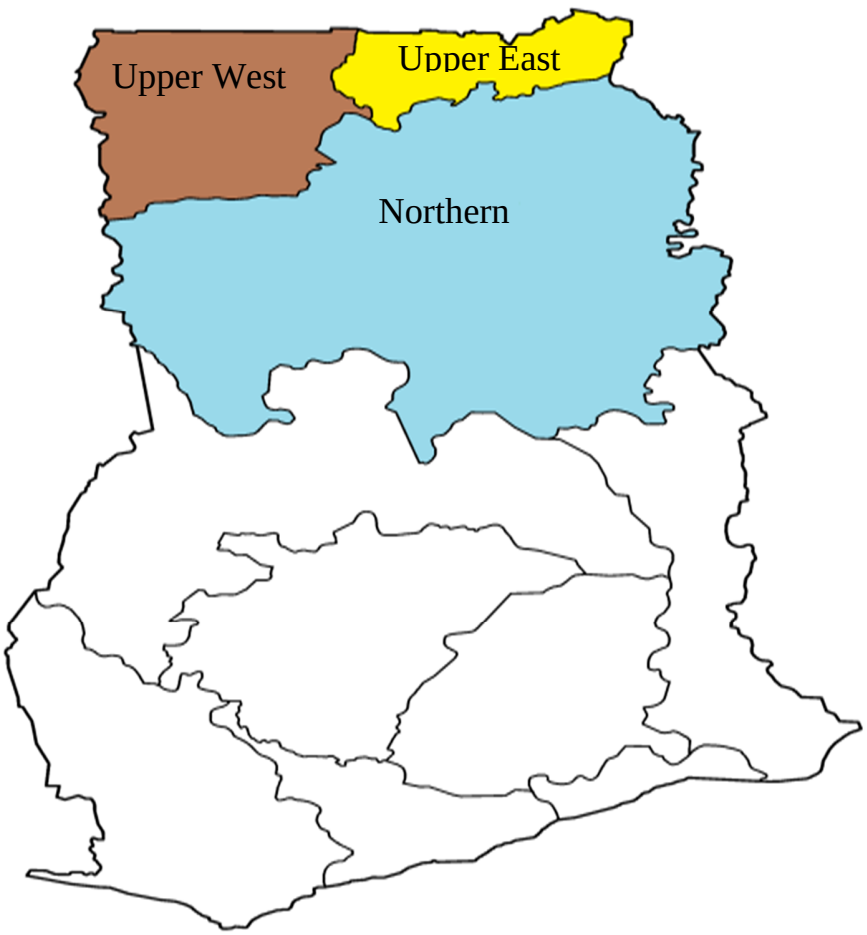

Figure 2: Map of Ghana showing the three Northern Regions

Source: Ghana Statistical Service (2014)

3.2 Questionnaire design

A questionnaire was designed to capture content and clarity on basic facilities and slaughter procedures of slaughterhouses in the three northern regions. The order of questions in the questionnaire was design to address the objectives of the study, the availability of infrastructure as well as slaughtering procedures and operational status of the slaughterhouses in the study areas. Questions 1 to 3 covered identification and location of the various abattoirs and slaughterhouses, questions 4 to 9 covered assessment

of the buildings of the slaughterhouses, questions 10 to 21 covered assessment of the environment of the slaughterhouses, questions 22 to 29 covered an assessment of safety wears of workers in the slaughterhouses, questions 30 to 44 covered assessment of equipment in the slaughterhouses, questions 45 to 57 covered an assessment of laboratories and storage rooms in the slaughterhouses, questions 58 to 60 covered assessment of staff adequacy in the slaughterhouses, questions 61 to 75 covered assessment of sanitary conditions in the slaughterhouses, questions 76 to 86 covered other auxiliary activities of the slaughterhouses and questions 87 to 100 covered assessment of slaughterhouses based on animal slaughtering procedures. Open- ended questions which made provisions for the respondent's comments and perceptions were included in the questionnaire. Closed- ended questions where the respondent's must choose from a list of options available were also included (Collins *et al.*, 2000).

The questionnaire was pre-tested by ten (10) independent persons in ten (10) slaughterhouses in Northern Region to ensure the questionnaire was fit for the purpose intended. The questionnaire pre-testing was also to ensure that the wording was simple and easy to read and understand by respondents.

3.3 Study design

This study was designed to be a field based research. Slaughterhouses were visited to gather information on physical infrastructure and to observe personally slaughtering practices in those slaughter facilities.

The study was conducted for a period of sixteen (16) weeks in the early wet season from April, 2017 to July, 2017 and involved visits to twenty slaughterhouses in the three

northern regions namely: Northern region (Tamale, Damongo, Salaga, Yendi, Daboya, Bole, Chereponi, Bimbilla, Gushegu, Tatale), Upper east (Bolgatanga, Sandema, Navrongo, Bawku, Fumbisi) and Upper west (Wa, Jirapa, Tumu, Hamile, Lawra).

3.4 Sources of data

The methods used in collecting data for the research were in two categories; primary sources and secondary sources. The primary source comprised interviews and personal observations. The secondary source comprised data from dissertations, articles, encyclopaedias, journals as well as websites.

3.4.1 Primary data collection

Primary data were collected through face-to-face interviews, observations and questionnaires. Slaughterers, butchers, meat inspectors/veterinary officers, sanitary officials (cleaners) and management of the various slaughterhouses selected in the study area were interviewed.

3.4.2 Sampling procedure

Twenty slaughterhouses were purposively chosen in the study area for this research. Out of the twenty slaughterhouses chosen, ten (10) were from the Northern region, five (5) from Upper east region and five (5) from Upper west regions of Ghana. The reason for the choice was that, enquiries were made from each region and it was found that the northern region had more communities with slaughterhouses than the other two regions in northern Ghana. This could be attributed to the fact that, northern region is the largest and carries more population than the other regions. Questionnaires were pretested and self-administered on the sample slaughterhouse workers between December 2016 and

February 2017 in hard copies to gather data on infrastructure, respondents' knowledge and preventive measures about slaughterhouse operations.

3.4.3 Data collection procedure

Visits were arranged with the various respondents in order to collect information from the slaughterhouses based on infrastructure and slaughtering operations of each slaughterhouse. Management of each slaughterhouse were pre-informed to make available the respondents (interviewees) to be interviewed and help to complete the questionnaire. Two consecutive days were spent in each slaughterhouse. On arrival on the first day, the researcher introduced himself to management and respondents in the slaughterhouses and stated clearly the purpose of the visit, the objectives of the study, the scope and the details of the study. The respondents were assured that the information given by them will be treated confidential and anonymity was assured. Informal interviews were conducted to obtain some categories of information from respondents. Questions in the questionnaire were asked in the same order to every respondent. Although the questionnaire was developed in the English Language, the interviewer translated the questions into the language the respondents were comfortable with. A total of twenty (20) semi-structured questionnaires were administered at twenty (20) slaughterhouses in the three northern regions. Each slaughterhouse was visited on two consecutive days to obtain the data necessary for the study. In the first day, a questionnaire was administered to five respondents (a butcher, a slaughterer, a meat inspector/ veterinary officer, a cleaner and the manager of the slaughterhouse). In the second day, the researcher observed how slaughtering activities were carried out, how cleaning including washing of tools/utensils, how the floor as well as the environment

(including waste management) was sanitized and lairage conditions in the slaughterhouse. It is noted that slaughter activities started around 7:00am and ended around 11: 30am in all the slaughterhouses visited during the study.

3.5 Secondary sources

Secondary data refers to data that is collected for some other purposes other than the research in question. However, information obtained from this data sources must be very well related to the study. Examples of secondary data sources include journals, magazines, textbooks, internet, websites, newspaper and articles. Some related shortcomings of secondary data however are that, it may be liable to alterations or fabrications, it may also not be presented in the preferred state and it may also be from an incorrect source. This study made use of secondary data very extensively during the literature review session of this work.

3.6 Problems encountered

The research area was comprised of multi-ethnic groups and varied languages as such communication between the researcher and some respondents was sometimes a big challenged. The researcher sometimes had to employ the services of an interpreter for effective communication. The next challenge the researcher faced was that, some of the butchers and veterinary officers were reluctant in providing certain information because they claimed they were uncertain as to how the researcher will use this information and this may have influenced the answers they provided. Again, northern Ghana covers a vast area and carrying out a research to cover that section of Ghana was not easy especially

movement from one research point to another to take data. This made the data collection process tedious and also financially involving since money was needed to facilitate the data collection process.

3.7 Data analysis

In analysing the data collected, the responses were classified and summarized on the basis of the information provided by the respondents.

The analysis was done using both qualitative and quantitative tools. Under the quantitative aspect of the analysis, chi square in Statistical Package for Social Sciences (SPSS) version 20 was used and the results presented in tables, figures and percentages. The qualitative aspect made use of descriptive presentations.

CHAPTER FOUR

RESULTS

For the purpose of this research, the slaughterhouses visited were categorised into five depending on the number of animals slaughtered daily. The frequencies of the respondents on the size of the slaughterhouses and the number of animals slaughtered daily are presented in the Table 1 below.

Table 1: Views of butchers on size of slaughterhouses and the number of animals slaughtered daily

Slaughter house	Number of animals	Frequencies of slaughter houses		Total frequencies
		Frequencies for yes	Frequencies for no	
Category 1	0- 10	0	1	1
Category 2	11- 20	1	6	7
Category 3	21- 30	1	7	8
Category 4	31- 40	0	3	3
Category 5	51- 60	1	0	1
Total		**3**	**17**	**20**

Source: **Field survey, 2017**

Figure 3 shows the slaughterhouses and the average number of animals slaughtered daily. The slaughterhouse that recorded the highest number of animals slaughtered daily was the Tamale abattoir (category 5) followed by Sandema (category 4) and Navrongo (category 4) slaughterhouses. Salaga slaughterhouse recorded the least number of animals slaughtered daily.

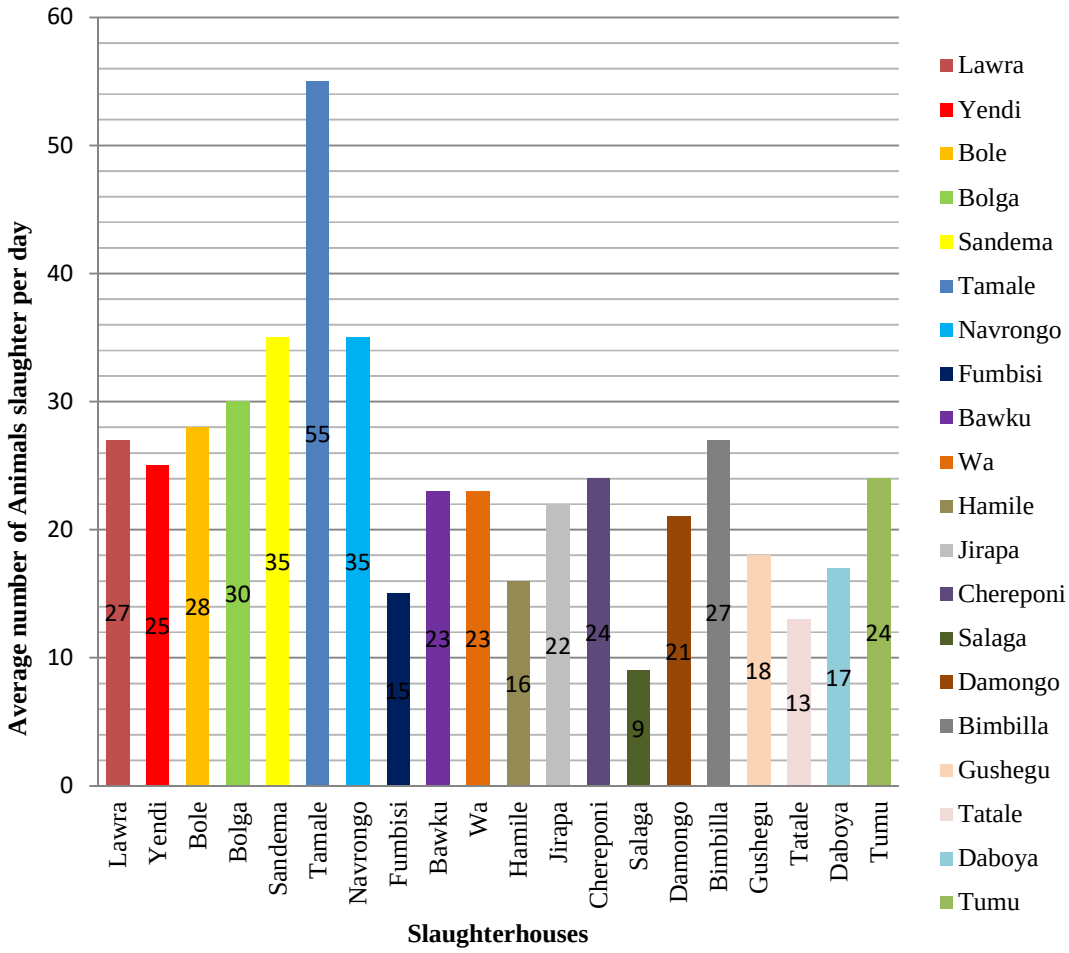

Figure 3: Average number of animals slaughtered per slaughterhouse daily

Table 2 shows the presence/absence of basic facilities that are necessary for the effective running of a slaughterhouse. From the data gathered, none of the slaughterhouses visited had stunning machines, cold-rooms and veterinary laboratories. One slaughterhouse (Tamale abattoir) had a fence and provided with pipe-borne water.

Table 2: Assessment of the slaughterhouses based on availability of basic facilities

SLH/ BF	FNC	LRG	STM	CD	H/R	DRGS	PBW	VL	ELC	W/R
Tamale	√	√	-	-	√	√	√	-	√	√
Bole	-	√	-	-	√	√	-	-	-	√
Bolgatanga	-	√	-	-	√	√	-	-	-	√
Tatale	-	-	-	-	-	√	-	-	-	-
Bimbilla	-	√	-	-	√	-	-	-	-	-
Chereponi	-	-	-	-	-	-	-	-	-	-
Gushegu	-	√	-	-	√	√	-	-	√	√
Wa	-	√	-	-	-	√	-	-	-	-
Hamile	-	√	-	-	√	√	-	-	-	√
Lawra	-	-	-	-	√	-	-	-	-	-
Fumbisi	-	-	-	-	√	√	-	-	-	√
Damongo	-	-	-	-	-	-	-	-	-	-
Yendi	-	-	-	-	√	√	-	-	-	-
Sandema	-	-	-	-	√	√	-	-	-	√
Navrongo	-	√	-	-	√	√	-	-	-	√
Daboya	-	-	-	-	√	√	-	-	-	-
Tumu	-	-	-	-	√	√	-	-	-	-
Salaga	-	-	-	-	-	√	-	-	-	-
Bawku	-	-	-	-	√	√	-	-	-	√
Jirapa	-	-	-	-	-	√	-	-	-	-
Percentages	5	40	0	0	70	80	5	0	10	45

Where: √= present, minus (-) =absent, SLH= Slaughterhouses, BF= Basic Facilities, FNC= Fence, LRG=Lairage, STM= Stunning Machine, CD= Cold Room, H/R= Hoist/Rail, DRGS= Drainage Systems, PBW= Pipe-Borne Water, VL= Veterinary Laboratory, ELC= Electricity and W/R= Washroom

Source: **Field survey, 2017**

Table 3 shows the presence and absence of safety wears and facilities in the slaughterhouses visited. None of the workers in the slaughterhouses used helmet, gloves and goggles during slaughtering operations. Only the Tamale abattoir had a fire extinguisher, water hydrant and a floored environment. Also, none of the slaughterhouses had a meat van.

Table 3: Assessment of the slaughterhouses based on safety wears and facilities

SLH/SW	SB	AP	HMT	HG	GLS	FE	WH	FEV	MV
Tamale	-	-	-	-	-	√	√	√	-
Bole	-	-	-	-	-	-	-	-	-
Bolgatanga	√	√	-	-	-	-	-	-	-
Tatale	√	√	-	-	-	-	-	-	-
Bimbilla	-	-	-	-	-	-	-	-	-
Chereponi	-	-	-	-	-	-	-	-	-
Gushegu	√	-	-	-	-	-	-	-	-
wa	√	√	-	-	-	-	-	-	-
Hamile	√	√	-	-	-	-	-	-	-
Lawra	√	-	-	-	-	-	-	-	-
Fumbisi	-	-	-	-	-	-	-	-	-
Damongo	-	-	-	-	-	-	-	-	-
Yendi	-	-	-	-	-	-	-	-	-
Sandema	√	√	-	-	-	-	-	-	-
Navrongo	-	√	-	-	-	-	-	-	-
Daboya	-	-	-	-	-	-	-	-	-
Tumu	-	√	-	-	-	-	-	-	-
Salaga	-	-	-	-	-	-	-	-	-
Bawku	√	√	-	-	-	-	-	-	-
Jirapa	-	√	-	-	-	-	-	-	-
Percentages	40	45	0	0	5	0	5	5	0

Where**:** √= in use, minus (-) = not in use, SLH= Slaughterhouses, SW= Safety Wears, SB= Safety Boots, AP= Apron, HMT= Helmet, HG= Hand Gloves, GLS= Goggles, FE= Fire Extinguisher, WH**=** Water Hydrant, FEV= Floored Environment and MV= Meat Van

Source: **Field survey, 2017**

Table 4 shows the presence/absence of slaughter sections in the slaughterhouses. None of the slaughterhouses visited had a scalding unit. Three slaughterhouses had skinning/flaying units, four had condemned units and eleven slaughterhouses had sections for evisceration.

Table 4: Assessment of slaughterhouses based on slaughter practices

SLH/SP	BS	S/FS	EVS	CSS	SS	CU
Tamale	√	-	-	√	-	√
Bole	√	-	-	√	-	√
Bolgatanga	√	√	-	√	-	-
Tatale	-	-	√	√	-	-
Bimbilla	-	-	√	√	-	-
Chereponi	-	-	√	-	-	-
Gushegu	√	-	√	√	-	-
Wa	√	√	√	-	-	√
Hamile	√	-	√	√	-	-
Lawra	√	√	-	√	-	-
Fumbisi	√	-	√	√	-	-
Damongo	√	-	-	√	-	-
Yendi	-	-	-	-	-	-
Sandema	√	-	-	√	-	-
Navrongo	√	-	-	√	-	-
Daboya	-	-	-	√	-	-
Tumu	√	-	-	√	-	-
Salaga	√	-	√	-	-	√
Bawku	√	-	√	√	-	-
Jirapa	√	-	-	√	-	-
Percentages	75	15	45	20	0	20

Where: √= present and in-use, minus (-) absent, SLH= Slaughterhouse, SP= Slaughter Practices, BS= Bleeding Section, S/FS= Skinning/Flaying Section, EVS= Evisceration Section, CSS= Carcass Splitting Section, SS= Scalding Section and CU= Condemned Unit.

Source**: Field survey, 2017**

Table 5 shows the meat inspection status of the slaughterhouses visited. Seventeen slaughterhouses representing 75% carried out meat inspection whiles 25% did not. Common diseases encountered by butchers during their routine meat inspections are also presented in the table.

Table 5: Meat inspection status and diseases in the slaughterhouses

Slaughterhouses	Meat inspection	Diseases encountered by meat inspectors
Tamale	√	Anthrax, cattle pneumonia
Bole	√	Cattle pneumonia, foot-rot
Bolgatanga	√	Cattle pneumonia
Tatale	-	-
Bimbilla	√	Tetanus, broken limbs
Chereponi	√	Cattle pneumonia, anthrax, cattle T.B
Gushegu	√	CBPP, cattle pneumonia
Wa	√	Cattle T.B, foot-rot
Hamile	√	Cattle T.B, anthrax
Lawra	√	Cattle T.B
Fumbisi	-	-
Damongo	√	Anthrax, foot-rot, cattle T.B
Yendi	√	Cattle T.B, skin lesions, Anthrax
Sandema	√	Heart water, cattle T.B
Navrongo	√	Cattle T.B, body lesions
Daboya	-	-
Tumu	√	Anthrax, Cattle pneumonia, broken limbs
Salaga	√	Tetanus, Cattle pneumonia
Bawku	√	Cattle T.B, skin lesions, anthrax
Jirapa	√	Cattle pneumonia, body lesions

Where: √= meat inspection practiced,−= no meat inspection
Source: **Field survey, 2017**

CHAPTER FIVE

DISCUSSION

5.1 Views of butchers on size of slaughterhouses and number of animals slaughtered daily

The slaughterhouses visited during this study were put into categories depending on the number of animals slaughtered per day. Category 1 represented the Salaga slaughterhouse; category 2 represented Daboya, Fumbisi, Hamile, Gushegu and Tatale slaughterhouses. Category 3 represented Bole, Bolgatanga, Tumu, Bawku, Wa, Jirapa, Chereponi, Damongo, Bimbilla, Lawra and Yendi slaughterhouses. Category 4 represented Sandema and Navrongo slaughterhouses. Category 5 represented Tamale abattoir.

From Table 1, the frequencies of respondents who indicated that the size of their slaughterhouses were sufficient for their daily slaughter was 15% (3/20). However the frequencies of respondents who responded that their slaughterhouses were not big enough for their daily slaughter was 75% (17/20). The frequencies for no support the claim of butchers in the slaughterhouses as they indicated that their slaughterhouses were not big enough for their daily kill. This prevents them from bringing a number of animals into the slaughter halls to slaughter and processed for meat at the same time. As such they could only kill and processed 2 or 3 animals (cattle) at a time. According to the butchers, this waste their productive time as they have to slaughter few animals at a time before the next kill.

The fewer number of animals slaughtered daily could also be attributed to other reasons. To begin with, lack of equipment in the various slaughterhouses could be one of the

reasons for the fewer number of animals slaughtered daily. Modern slaughter equipment is paramount in large scale meat production and processing. For an abattoir or a slaughterhouse to produce meat to meet consumer demands, it should be well stocked with modern equipment to support large scale meat production. In the developed countries, commercial abattoirs have sophisticated machinery for meat production (Gregory, 2005) while most municipal abattoirs have poor handling facilities (Ndou *et al.*, 2011). It could also be attributed to the poor environmental and sanitary conditions that engulf the slaughterhouses in the study areas. The poor sanitary conditions could deter the public especially the rich and high income earners who perceive those slaughterhouses as unfit places for meat production. Also, the fewer number of animals slaughtered daily could be attributed to the season in which this research was conducted. This study was carried out during the peak of the raining season and most of the paths to the communities were in bad shape and characterized by stagnant waters and bushes grown to cover most places. This could prevent butchers from going into the interior villages to procure animals for slaughter, as it is mostly the case in northern Ghana. In addition, farmers may also feel busy with their farm work which could prevent them from bringing animals to the market centres for sale.

5.2 The various slaughterhouses showing the average number of animals slaughtered daily

Tamale abattoir had the highest number of animals slaughtered daily as shown in Figure 3. The highest number of animals slaughtered daily at this abattoir could be attributed to the size of the facility and the equipment available. It can also be attributed to the size of

population of Tamale as it is the capital city of northern region and a cosmopolitan, and many people may be buying their meat produced from the abattoir.

Slaughterhouses that recorded the second highest numbers of animals slaughtered daily were from Sandema and Navrongo in the upper east region of Ghana. The least number of animals slaughtered daily was recorded at the Salaga slaughterhouse in the northern region. According to management of the Salaga slaughterhouse, most butchers refused sending their animals to slaughter in the slaughterhouse because they have to pay tax to the District Assembly if they are to do same. They stated that, twenty (20) Ghana cedi was paid on each cow slaughtered and five (5) Ghana cedi on goats and sheep. According to them, the Assembly does little or nothing towards the well-being of the slaughterhouse and the butchers. The economic and financial status of butchers could determine the quality of animals they buy (Shima *et al.*, 2015). As a result many butchers and individuals slaughter their animals in their homes and meat selling points. This agrees with the report of Hajimohammed *et al.* (2014) who reported that home slaughtering (slaughtering of animals outside slaughterhouses) is a common phenomenon in Iran and is usually done during religious ceremonies. It was also found that, only the Bolgatanga abattoir was engaged in poultry (guinea fowl) slaughter, even though it was not part of their main slaughter activities.

5.3 Assessment of the slaughterhouses based on availability of basic facilities

For security and sanitary reasons it is important that slaughterhouses be provided with a fence. This is to prevent unauthorized persons and animals from easy access to the interior of the slaughterhouses. From Table 3, it was realized that only the Tamale abattoir had a fence. This shows that 95% of the slaughterhouses were not fenced

allowing stray animals and unauthorized persons easy access to the premises of the facilities. When unauthorized people and animals are prevented from accessing the interior especially the slaughter line and other processing areas it will help reduce cross contamination. Akpabio *et al.* (2015) reported that an abattoir should be fenced to keep out predators and scavenger animals. The absence of the fence could also be a chance for thieves to easily carry away items belonging to the slaughterhouses.

Ideally it is important that slaughterhouses be provided with lairages. This will enable animals that are brought to the slaughterhouse to have some rest before they are taken for slaughter. However from Table 2, eight slaughterhouses representing 60% (12/20) in this study had no functional lairages. This is in agreement with the reports of Hassanien *et al*. (2015) who mentioned that there is no area for pre-slaughter rest which hinders ante-mortem inspection in some Egyptian slaughterhouses. This indicates that, animals are slaughtered immediately they arrive at the slaughter facilities. Long journeys are reported to have negative effects on the quality of meat. Meat quality can be improved by reducing animal stress, and the quality and value of hides and skins can be increased (Heinz and Srisuvan, 2001). As a result, animals must be given enough rest before they are taken for slaughter. Frimpong *et al.* (2012) attested that long journey of cattle, especially without rest, affects the welfare of slaughter animals. A lairage was observed serving both small and larger animals in the Bolgatanga abattoir. Mummed and Webb (2015) reported that lairages in some abattoirs in Ethiopia were constructed as one to accommodate different classes and types of animals.

Stunning animals before slaughter is important as it guarantees the safety of both the animal and slaughterers. However as important as stunning is, it was not practice by

slaughterers in all the slaughterhouses visited. This agrees with the findings of Ofosu-Koranteng (2010) who reported that the process of stunning animals before slaughter was never observed in the Tulaku slaughterhouse and this is viewed often as an inhumane act. Also, none of the slaughterhouses had equipment for stunning and restraining purposes. This agrees with the findings of Murshidul *et al.* (2014) who reported that modern restraint devices are not available in local slaughterhouses. As a result slaughterers have to wrestle with animals in trying to tie their legs with ropes as a means of restraining them for slaughter. This agrees with Ewbank and Parker (2007), who observed that ropes are used worldwide to restrain and handle cattle; however, there are a multitude of regional and local variations, with few of them having been formally documented or researched. Ofosu-Koranteng (2010) also indicated that, animals were restrained with ropes and slaughtered on the slaughter floor at the Tulaku slaughterhouse. Most at times animals were also slaughtered in the full glare of their mates. This was a common practice observed in most of the slaughterhouses visited. It was also observed that sometimes animals after bleeding vocalize loudly as a way of showing their discomfort and the pain they suffer in the hands of slaughter men prior to slaughter. This is supported by the findings of Heinz and Srisuvan (2001) who reported that occasionally, animals were capable of vocalizing for several minutes after bleeding, indicating that the animals could still feel pain. During an interaction with some of the butchers and slaughterers, the researcher wanted to know why they do not practice stunning before slaughter. The reason given was that stunning waste time. Considering the number of animals slaughtered daily, wasting a lot of time on an animal because of stunning will hinder their work and may reduce their daily earnings.

Ideally, the slaughter line of a slaughterhouse should be provided with rails for hanging carcass during dressing to prevent it from touching the floor. This will help provide wholesome meat to consumers as there will be no soiling of carcass with rumen content and faecal matter. From Table 2 five slaughterhouses representing 25% had no rails for hooking carcass during dressing. Hanging carcasses immediately after slaughter will help in proper blood drainage. It may also help in providing tender meat because of the tension the muscles will experience when hanged. Warriss (2000) reported that hanging carcasses by hooking the hind legs puts many muscles into tension and stretches the sarcomere lengths which may produce meats that are tender. This agrees with the findings of Igwe (2005) who reported that, hoist systems are not available in some abattoirs and this means improper draining of blood from the animal which also affects the quality of the carcass. Also, this means that slaughterers do almost all their slaughter activities on the bare floor. This practice makes the carcass soiled with rumen content and faecal matter if proper care is not taken. As a result, the meat becomes unwholesome and not appealing to the consumer. Also, there were no functional hoist systems in all the slaughterhouses visited. The hoists help in blood drainage in carcass immediately after slaughter to prevent early meat spoilage by microorganisms. Igwe (2005) observed that improper drainage of blood affects the quality of carcass of slaughtered animals. Lawan *et al*. (2013) reported that some butchers and slaughterers rejected the idea of hanging rail system for the reasons that many workers will be redundant if the line system is employed for carcass processing. The second reason that was given was that, the hanging rail or hoist system takes longer time to process a single animal slaughtered. Nevertheless the reason in the second point given above was not encountered during this study.

From Table 2, it was found that none of the slaughterhouses visited had cold rooms and refrigerators for carcass preservation. This agrees with the findings of Lawan *et al*. (2013) who reported that, there was no importance attached to cold room in some abattoirs in north-western states of Nigeria for the reason that animals were slaughtered, processed into carcasses and sold to consumers on the same day. They also had it that, in the Kano abattoir, meat that was not sold in the market was stored in the cold room to be sold the next day. The only slaughterhouse with a cold room was found in Tamale abattoir. However it was non-functional at the time of this study. This is supported by the report of Fearon *et al.* (2014) who indicated that the Tamale abattoir lacks basic facilities including cold storage facility despite the vast potential of the industry. Carcasses and other meat products which are intended to be used later needs to be stored in the cold room with the right temperature to prevent microbial attack on meat. Various preservation techniques are available, and aimed at improving meat quality by increasing shelf life for a longer time as fresh meat is an ideal medium for the growth of both spoilage and pathogenic organisms (Adzitey *et al.*, 2010; Adzitey *et al.*, 2011). However the lack of cold rooms in the slaughterhouses forced butchers to produce the quantity of meat they can manage or sell for the day. This means they cannot produce more for the fear that they might not be able to sell all in a day and the remaining meat and meat products may go bad. This reduces productivity and income of the butcher and animal producers.

Guttery and drainage systems are essential for waste collection and treatment in the slaughterhouses. Liquid waste forms the major portion of waste generated from the slaughterhouses daily due to washing of carcasses and equipment. During this study, it

was found that sixteen (16) slaughterhouses representing 80% had guttery systems whiles four (4) slaughterhouses representing 20% had none. This indicates that during slaughtering operations the floor of the slaughterhouses without gutters will be smeared with effluent discharges and blood from slaughtered animals. These can be a source of contaminant to the meat produced. It can also cause slippery and fall of personnel who work in the slaughterhouse. This could lead to injuries of slaughterers and also animals that are brought in to slaughter. Also, solid waste was dumped in front and very close to some of the slaughter facilities visited during this study. For hygienic and safety reasons, it is important that slaughterhouses be provided with drainage and guttery systems for effective discharge of both solid and liquid waste.

Veterinary/microbial laboratories are essential in the meat industry, more especially in slaughterhouses. However during this study, it was found that none of the slaughterhouses had laboratories for analysis of meat, blood, fluid and faecal samples taken from animals suspected of harbouring diseases. Annan-prah *et al.* (2012) stipulated that, the lack of laboratories attached to slaughterhouses appears to be logistic and personnel reasons. Because of the role laboratories plays in investigating causes of carcass condemnation and contributing to epidemiological data, it is imperative that they should be part of slaughterhouses, so that apart from microbiological investigations, there can be a snap checks on antibiotic and pesticide residues in meat (Warriss, 2001). The absence of laboratories shows that there will be no effective meat inspection especially post-mortem and consumers are likely to consume contaminated meat and its products. Bello *et al.* (2008) reported an absence of ante-mortem inspection in most abattoirs in Northern Nigeria.

Ideally it is important that slaughterhouses be provided with electricity. Electricity in slaughterhouses is not only provided to brighten the slaughter line but serves as security and sanitary measures. However it was found out that fifteen slaughterhouses representing 75% had no electricity system. This agrees with the findings of Akpabio *et al*. (2015) who reported an absence of electricity system at the Aba abattoir in Nigeria. Electricity is required in the slaughterhouse for use in automated dressing line of carcass dressing, refrigeration and lightening of slaughter halls for adequate visibility during slaughtering activities and cleaning procedures (Lawan *et al*., 2013). Aside hydro-electric power, other power sources such as generators and solar panels could be substitutes to help in the lightening system in the slaughterhouses in the case of power fluctuations or outrages. Proper lightening system will help check the movement and activities of rodents and reptiles such as mouse, lizards, wall gecko and other pest that serves as nuisance and disease-causing organisms. Murshidul *et al.* (2014) reported that at the larger abattoirs, the workers were under time constraints and had insufficient lightening in overcrowded locations. As a result, the slaughter lines of some of the slaughterhouses were dark and not visible enough for effective slaughtering operations. Lack of electricity and potable water supplies together with the poor status and unhygienic conditions of these abattoirs raises serious public health concern, as hygiene problem are not only limited to slaughtering but are also associated with incorrect processing (Akinro *et al.*, 2009).

A slaughterhouse should have adequate water supply for the smooth running of the facility especially with regards to washing of carcasses and equipments.

Pipe-borne water is essential for safe meat production and processing. However during this study, it was realized that only Tamale abattoir representing 5% had pipe-borne water. The rest of the slaughterhouses with a percentage of 95% sourced water from boreholes, wells or dams for meat processing. Also, in the Tamale abattoir, butchers obtained water from truck pushers and head porters who sold water from unknown sources for abattoir activities. This is in agreement with the reports of Lawan *et al*. (2013) who observed that, water was usually obtained from truck pushers, who sold water from unidentified sources for carcass washing. Water from these sources may not be good for human consumption as it might contain debris and faecal matter. This agrees with the findings of Lawan *et al*. (2013) who reported that all the abattoirs in north-western states of Nigeria had no regular supply of potable water and electricity. The water used for cleaning procedures must meet drinking standards (Fonseca, 2000). Also, the use of non-portable water by meat producers in this work might have contributed to carcass contamination as previously indicated by Bello *et al.* (2011) who observed increase in *E. coli* counts and isolation of *E. coli* O157H7 from beef carcasses in some Nigerian abattoirs due to the use of non-portable water.

Slaughterhouses should have well designed washrooms and provided with taps, detergents and antiseptics for proper hand washing and general personal hygiene. This will help in the proper hand washing of workers who visit the washroom. However during this study, it was found that thirteen slaughterhouses representing 65% had no washrooms for workers and staff. The remaining 45% had urinals provided for their workers as washrooms. This shows that there were no well design structures for use as washrooms in the slaughterhouses visited. This is contrary to the findings of Ofosu-

Koranteng (2010) who reported the presence of washed rooms provided for staff at the Tulaku slaughterhouse but was not equipped with liquid soaps or hand sanitizers. Maintenance of proper hygiene within the slaughterhouse and the environment, target areas for sanitization include: infrastructures and facilities contained therein, equipment, surrounding areas, abattoir workers and visitors (Olanike, 2002). The absence of washrooms in the slaughterhouses indicates that personnel directly involved in meat production could be sources of contamination if they visit the washroom without proper hand washing. The lack of most basic facilities coupled with non-functional facilities and the level of dilapidated infrastructures recorded in this study could not have supported standard operating procedures and good hygiene practices in the slaughterhouses and this situation may pose danger to public health as pointed out by Adeyemo (2002) in Bodija abattoir in Ibadan, Nigeria.

5.4 Assessment of the slaughterhouses based on safety wears and facilities

For effective meat production in the slaughterhouses, it is important that safety rules and regulations be strictly followed and applied in meat production. Safety rules if strictly followed by workers will help prevent most accidents and injuries in the slaughterhouses. Table 3, it was realized that majority of the workers in the slaughterhouses representing 60% were not using safety boots during slaughtering operations. When the researcher enquired to know why they do not use safety wears, they responded that they do not have safety boots. Also, some of the workers indicated that they feel more comfortable in their normal wears than the safety boots. There were no written minimum sanitary measures to be followed by workers in some slaughterhouses in Egypt (Hassanien *et al.,* 2015). Observing safety rules will safeguard workers in the slaughterhouses and the animals

(during slaughtering) to be used for food. However eight slaughterhouses (Lawra, Bolgatanga, Sandema, Bawku, Wa, Hamile, Gushegu and Tatale) representing 40% used safety boots during slaughtering operations. Alhaji and Baiwa (2015) observed that only few proportions of the workers in north-central Nigeria have knowledge about protective materials such as the use of apron, hand gloves and rubber boots and very few have knowledge about the use of face mask, eye goggles and washing of hands with soap after touching raw meat.

It was also found that eleven slaughterhouses representing 55% had workers who do not use apron during slaughtering operations. This agrees with the findings of Alhaj and Baiwa (2015) who attested that workers in the slaughterhouses of north-central Nigeria gave little attention to safety wears. They also added that, only 16.0% of workers in the slaughterhouses periodically use rubber boots, while 18.5%, 5.1% and 0.5% use aprons, hand gloves and eye goggles respectively.

Nonetheless the rest of the slaughterhouses that used aprons did not give attention to its cleanliness. They used dirty aprons during slaughter operations. This agrees with the findings of Mummed and Webb (2015) who reported that personnel at some abattoirs did not wear clean aprons, clothing, boots, mesh gloves and hair caps during meat processing. Hassanien *et al.* (2015) also mentioned that clothes of workers are dirty throughout the working days and their hands were not cleaned. Though most workers in the slaughterhouses had no aprons, they had substitute clothes for slaughtering operations. They hanged these cloths in the slaughterhouses daily after operations. However they pay little attention to its cleanliness. They picked them and wear the next

day for work. The remaining slaughterhouses (Jirapa, Bolgatanga, Sandema, Navrongo, Tumu, Bawku, Wa, Hamile and Tatale) representing 45% had their workers using aprons.

Wearing safety helmet in the slaughterhouse especially at the slaughter section is very important for the safety of the worker. Any loose structure hanging on the roof or above the head level can fall and injure workers in the slaughterhouses. As a result, it is important that safety helmet be worn to prevent accident on the head. However during this study, it was found that none of the slaughterhouses visited had workers who use safety helmet. They exposed themselves and more especially their heads to danger working in the slaughterhouses bare-headed.

The illness and injury level of workers was higher in slaughterhouses than in any other industry for "much of the last quarter of the twentieth century" (Broadway and Stull, 2008). Any institution that is into food production, especially those directly involved with meat must ensure that their workers observe good personal hygiene and obey safety rules and regulations. The hand is directly involved with the food and if not properly kept can be a source of contaminant. As such the hand must be properly clean and insulated with hand gloves to prevent possible cross-contamination. In addition to hand gloves, it is important that safety goggles be worn to prevent pieces of items from falling into the eyes. Personnel who are working in the bleeding section, evisceration and carcass splitting sections must wear goggles to prevent pieces of broken bones and other items from falling into the eyes and causing injuries. During this study it was realized that none of the slaughterhouses visited had their workers wearing both hand gloves and goggles. This goes contrary to the findings of Mummed and Webb (2015) who reported that

wearing of protective clothes was practiced by workers in both public and private abattoirs in Ethiopia.

As a matter of safety, it is necessary to provide slaughterhouses with fire extinguishers and blankets to help in putting out fires that may accidentally occur in the slaughterhouses. Fire can occur at any point in time in the slaughterhouse considering that it is used in singeing carcasses and providing hot water for washing of carcasses and equipment. However during this study, it was realized that only the Tamale abattoir representing 5% had a fire extinguisher and a water hydrant around. Areas such as the scalding and flaying sections of the slaughterhouses are more prone to fire out breaks because they deal with fires during operations. Gas and electricity which serve as sources of fuel for providing hot water and naked flame can cause fire outbreaks in the slaughterhouses. It is therefore important that, slaughter facilities be equipped with fire fighting gadgets to help put out possible fires whenever it occurs. This is supported by the findings of Amoako (2014) who revealed that, only few house owners within the Kumasi metropolis comply with portable fire extinguishers to fight unexpected fire outbreaks.

In addition to fire extinguishers, it is important that water hydrants be provided in the premises of the slaughterhouses. These will help in providing water when fire fighters come to put out fires that may occur in the slaughterhouses.

During this study, it was found that only the Tamale abattoir representing 5% had portions of its environment floored and part levelled with gravel and enclosed in a wall fence. Nineteen slaughterhouses representing (95%) were either engulfed in filth or in weeds. A clean environment will help prevent reptiles such snakes from getting access to the slaughterhouse especially the interior part of it. For safety and sanitary reasons, it is

required that both the interior and exterior parts of slaughterhouses be floored with non-slippery materials preferably with pavement blocks. A floored environment will aid in easy movement and cleaning both in and around the slaughterhouse. Hot water with ordinary detergent facilitates easy and quality washing of abattoir floor and equipment (Lawan *et al*., 2013).

From Table 3, it was found out that none of the slaughterhouses visited had meat or cold vans for carcass transportation. This agrees with the findings of Ofosu-Koranteng (2010) who observed that cold vans were not available to transport the slaughtered animals from the Tulaku slaughterhouse to other markets. Also for hygienic reasons, it is necessary that meat meant for human consumption be given the best attention during transportation to prevent cross-contamination and spoilage. The vehicle meant for carcass transportation must be insulated and provided with cold rooms or refrigerating systems to help preserve the meat until it gets to its final destination. The absence of meat vans in the slaughterhouses necessitated butchers to transport meat in open trucks and in tricycles commonly called ’motor king’ and on motorcycles and bicycles. At times apprentices of butchers who were sent to convey carcass to selling joints were spotted sitting on carcasses in the tricycles during transportation. Some butchers also piled up carcasses of small ruminants such as goats and sheep on the petrol tanks and back seats of their motorcycles during transportation. These actions of butchers completely disregard their own safety and they can also be a source of contaminant to meat.

With all the observations made in the slaughterhouses with regard to safety, it was concluded that, all the slaughterhouses visited during this study did not attach seriousness to safety rules and regulations during meat production. Though none of the

slaughterhouses visited obeyed safety rules and regulations during meat production, the Tamale abattoir however, had some basic safety equipment such as boots and fire extinguishers. The reason that could be attributed to this is because it attains the status of an abattoir and expected to have most equipment than the other slaughterhouses.

5.5 Assessment of the slaughterhouses based on slaughter practices

Ideally, a slaughterhouse should have a place demarcated for bleeding purposes. This is where animals meant for meat are sent for bleeding before their carcasses are taken for skinning and evisceration. From Table 4, it is found that majority of slaughterhouses representing 75% had areas demarcated for bleeding animals. However five slaughterhouses (Tatale, Bimbilla, Yendi, Daboya and Chereponi) representing 25% had no bleeding sections. As a result bleeding was done at any place within the premises during slaughtering operations. Akpabio *et al.* (2015) reported that animals are slaughtered in slaughter halls in Aba abattoir in Nigeria.

Also, during this study, it was found that majority of the slaughterhouses representing 85% had no sections for skinning and flaying of carcasses. This means that bleeding and skinning was carried out at any spot within the slaughterhouses. During this study, it was found that three slaughterhouses (Bolgatanga, Wa and Lawra) representing 15% had areas for skinning and flaying purposes.

Again, it was observed that nine out of twenty slaughterhouses representing 45% had sections for evisceration. However majority of the slaughterhouses representing 55% had no platforms for evisceration purposes. This means that, evisceration was done at the same spot after skinning. This agrees with the report of Akpabio *et al.* (2015) who observed the absence of evisceration section in the Aba abattoir.

Carcass splitting requires a raised platform where carcass is neatly packed for effective cutting into the required cuts. This is to prevent the carcass from touching the floor and possibly soiling rumen content and other dirt within the surrounding. From Table 4, it was found that sixteen slaughterhouses representing 80% had raised platforms demarcated as a carcass splitting areas. Four slaughterhouses (Wa, Chereponi, Salaga and Yendi) with a percentage of 20 had no carcass splitting areas. Carcass splitting was done on the same spot as bleeding and skinning.

A serious meat production facility must have equipment and hot water providing unit for scalding of carcasses during carcass preparation. On the contrary, it was realized that none of the slaughterhouses visited had hot water providing equipment and scalding units for carcass preparation. As such none of the slaughterhouses visited was seen engaged in carcass scalding during this study. Supply of hot portable water in abattoirs is important because of the fatty nature of products in the abattoir (Lawan *et al.*, 2013).

A slaughterhouse should have a carcass condemning unit where diseased carcasses or carcasses which are contaminated beyond human consumption are sent for condemnation. This is to prevent cross contamination between diseased and healthy meat. The aim is to prevent diseased or unwholesome meat from getting into the market. During this study, it was found that four slaughterhouses (Tamale, Bole, Wa and Salaga) representing 20% had units for carcass condemnation. However sixteen slaughterhouses representing 80% had no carcass condemning units. Although, the Tamale abattoir had a condemn room, it was not in use at the time of this study. As a result, partial carcass condemnation was seen carried out in the same hall as the other slaughtering activities.

Also, many slaughterhouses did partial carcass condemnation but had no condemned rooms or units.

Slaughterhouses generates a lot of waste especially liquid waste due to the washing of carcasses, the walls and floors of the slaughterhouses, equipments and water used for further meat processing operations. However during this study, it was observed that wastes in the slaughterhouses were not given serious attention. There were no proper waste management systems to ensure effective waste disposal in all the slaughterhouses visited. Wastes which include both solid and liquid waste were littered all over the surroundings of the slaughterhouses posing danger to public health.

5.6 Slaughter procedures

Slaughter observations were made in all the twenty slaughterhouses visited. The aim was to find out how slaughter processes are carried out during meat production in the various slaughterhouses.

5.6.1 Casting and restraint

In all the slaughterhouses visited, animals meant for slaughter were dragged into the slaughter rooms with force by two or more men. Murshidul *et al*. (2014) reported that generally, two men were sufficient to restrain an animal at local abattoirs in Bangladesh. However, in cases were animals seemed wild or gregarious; more men were needed to help in the restraint. Mostly a long rope was used to prevent the animal from hitting the one pulling it in front with its head. The other one follows behind the animal and controls it with a stick. Rough casting procedures caused stress, pain and the mistreatment of animals (Murshidul *et al*., 2014). It was also observed in the Tamale abattoir, Salaga

slaughterhouse, Wa slaughterhouse, Bolgatanga slaughterhouse, Bawku slaughterhouse and Damongo slaughterhouse that, animals were dragged into the slaughter areas by holding and twisting their tails. The use of an upright restraint instead of casting is highly recommended (Murshidul *et al.*, 2014).

Also, the floors of most of the slaughterhouses were slippery especially when they were in full operation and the floor became wet with effluent discharges and water used in washing the viscera of the animals slaughtered. Some of the slaughterhouses including the Tamale abattoir had the slaughter areas floored with polish tiles; this could increase the intensity of the slippery nature of the floors especially if it is wet with blood and other substances like water and fat. In the slippery floors, it was observed that animals fell down immediately they entered the slaughter section and bleeding effected at that spot with the animal head pressed down by energetic young men with the aid of its horns.

Other places where the floors were non-slippery, the animal to be slaughtered was dragged in with one person pulling it with a rope in front and the other person chasing it from behind to the slaughter area. The animal was brought down by the two or more men with the aid of twisting the neck using its horns and pulling the tail simultaneously until the animal finally gets to the floor. The four legs were brought together and roped by one person. This agrees with the findings of Murshidul *et al.* (2014) who reported that, one person roped all four of the animal's legs while the second held her head down prior to slaughter at the local abattoirs in Bangladesh. The one to effect the sticking was given a knife quickly to do the sticking. The methods of casting and restraint observed in this study completely disregard the welfare of meat animals in the slaughterhouses.

5.6.2 Sticking and bleeding

From Table 4, it was found that five slaughterhouses (Tatale, Bimbilla, Chereponi, Yendi and Daboya) representing 20% had no areas demarcated for bleeding purposes. This indicates that bleeding was done at any spot within the slaughter halls.

Concerning bleeding procedure, it was observed that, as soon as animals were brought to the floor, sticking was carried out within seconds with mostly backward and forward stroke with a sharp curved knife. This contradicts the reports of Murshidul *et al.* (2014) who indicated that bleeding of animals was slow and there was a reason to believe that flaying occasionally begun before the animals lost consciousness. After sticking the neck of the animals was turned towards the drains for bleeding. Blood was seen gushing out as soon as the throat was cut. After sticking, the carcass of the animal slaughtered is obtained (Warriss, 2000; Adzitey, 2011). However stunning was not practice in all the slaughterhouses visited. Also, animals were bled the halal (Islamic) method and sticking done by Muslims in all the slaughterhouses visited. This agrees with the findings of Akpabio *et al.* (2015) who reported that animals in the Aba abattoir were slaughtered using the halal method on the bare floor with flaying of the carcass taking place on the same spot. At the sticking stage, a sharp knife was placed on the throat and the name of Allah mentioned with some Arabic incantations before the throat was finally cut with the knife. The halal guidelines were not followed, except for voicing the name of Allah while cutting the throat. According to the slaughterers, the Arabic incantation was a way of inviting Allah into the meat to make it lawful for Muslim consumption. In some cases animals were pressed down with both the knees and hands of butchers until it was confirm dead before they release it. Smaller animals such as goat and sheep were

slaughtered with one man pressing the animal down with his feet on the limbs of the animal and the slaughterer doing the sticking by pressing the head of the animal backwards with the left hand, straightening its neck to expose the veins for sticking. Sticking was generally done by the right hand. In all two men were seen involved in small ruminant slaughter. However sticking and bleeding were done on the bare floor in all the slaughterhouses visited. This is in line with the findings of Mummed and Webb (2015) who reported that, in all public abattoirs, bleeding was conducted on the floor on horizontal position. Even though horizontal bleeding promotes faster bleeding rates (Red Meat Abattoir Associations, 2011), it is not as hygienic as vertical bleeding.

5.6.3 Skinning and hide removal

During this study, it was found that, three slaughterhouses (Bolgatanga, Wa and Lawra) representing 15% had areas demarcated for skinning and flaying purposes. This showed that the rest of the slaughterhouses probably perform skinning of carcasses at any spot within the slaughter halls.

Concerning skinning procedure, it was observed that after bleeding, skins of some of the animals such as cattle were removed by the use of a knife and bare hands.

Nevertheless the skinning processes were conducted on the bare floor in all the slaughterhouses visited. This is in agreement with the findings of Mummed and Webb (2015) who observed that, flaying of the skin was conducted on the floor. Also, it was observed that throughout the skinning processes, the head was never skinned, but were removed together with the entire skin. The head was later singed together with the skin, limbs and the tail. During an interaction with some of the butchers, the researcher wanted

to know the reason why the head and limbs were not skinned but left intact. Two reasons were given by the butchers: the first reason was that, the skin adds up to the weight of the head and limbs and this gives a good amount when sold. The second reason was that, consumers prefer the head, limbs and tail singed intact and wash well with water to give a brighter colour. In general, skinning was done manually in all the slaughterhouses visited. There were no machines for mechanical skin or hide removal.

5.6.4 Evisceration and viscera removal

From Table 4, it was found that nine slaughterhouses representing 45% had areas demarcated for the removal of internal organs and effluent of slaughtered animals. This showed that the rest of the slaughterhouses do the evisceration process at any portion of the slaughter halls. This could affect the quality of the carcass produced if proper attention is not paid during carcass preparation.

Evisceration was carried out on the bare floor in all the slaughterhouses visited. This agrees with the findings of Ofosu-Koranteng (2010) who reported that the evisceration process was carried out on the floor instead of an elevated position at the Tulaku slaughterhouse. Also, butchers did not wear protective hand gloves during the evisceration process in all the slaughterhouses visited.

5.6.5 Carcass splitting and cutting

From Table 4, it was found that four slaughterhouses (Chereponi, Wa, Yendi and Salaga) representing 20% did not have areas demarcated for carcass splitting. This shows that carcass splitting was done at the same spot as the other slaughter processes.

Concerning carcass splitting procedure, it was observed that during the skinning process, the limbs and head of bigger animals such as cattle were removed together with the skin. After evisceration, the carcass was divided into two halves along the backbone with a sharp axe and a machete. This was observed mostly during cattle carcass splitting process. After dividing the carcass into two halves, each half was taken through post-mortem inspection by meat inspectors. After the inspection, each half was divided into two for easy handling and transportation. This agrees with the findings of Adzitey and Huda (2012) who reported that for easy handling, transportation and processing of animals, their carcasses are divided into portions after slaughter. Also, carcasses of small ruminants such as goats and sheep which were skinned went through the same splitting procedures like that of the cattle. However, carcases of small ruminants that were singed were transported to meat shops in the market whole without splitting it. This could affect the quality of the meat as it could be soiled with rumen content and other intestinal fluids.

5.6.6 Scalding/singeing section

In a standard slaughterhouse, scalding and singeing equipments are installed to make provisions for the scalding of animals such as goat, pig, sheep and poultry. However from Table 4, it was found that none of the slaughterhouses had equipments for scalding and singeing purposes. It was also observed that old car tyres and firewood were the major sources of fuel for singeing carcasses in all the slaughterhouses visited.

5.6.7 Isolation block

From Table 5, it was realised that none of the slaughterhouses were provided with isolation blocks. This shows that diseased animals were either put at any place within the

slaughterhouse or slaughtered depending on the degree of the sickness or diseases. As a result, diseases could be transferred from one animal to another or spread among animals. Also, unwholesome meat may be produced and sent out for public consumption.

5.6.8 Carcass and meat inspection

From Table 5, seventeen slaughterhouses representing 85.0% practiced carcass and meat inspection. This was carried out by trained meat inspectors and veterinarians employed by the district assemblies of the study areas. This is in agreement with the findings of Ofosu-Koranteng (2010) who indicated that, carcasses were subjected to inspection by a veterinary officer in the Tulaku slaughterhouse. However slaughterhouses such as Tatale, Fumbisi and Daboya representing 15.0% did not practice ante-mortem and post-mortem meat inspection at the time of this study. This agrees with the findings of Bello *et al*. (2008) who reported the absence of ante-mortem inspection in most abattoirs in Northern Nigeria. This goes contrary to the reports of Mummed and Webb (2015) who reported that both ante-mortem and post-mortem carcasses and organs inspection were conducted in all abattoirs visited in Ethiopia. However there was no inspection of the brains of slaughtered animals in any of the slaughterhouses during this study. The brain is reported to harbour many infectious diseases that could affect the health of consumers. It was observed in the Tamale abattoir that, carcasses declared fit for human consumption were stamped to distinguish it from carcasses yet to undergo inspection. However this was not observed at the rest of the slaughterhouses even though carcass inspection was carried out. Carcasses passed as fit were hanged separately from unfit carcass without any stamp. Also it was found that meat inspection was seen effective on cattle with little attention to small ruminants (goats and sheep). For instance, in the Tamale abattoir where many goats

and sheep were slaughtered, majority of their carcasses were not taking through post-mortem inspection. Full attention was paid to the carcasses of cattle. When the researcher enquired to know why post-mortem inspection was only carried out on cattle, the veterinarian in charged replied that, their number was not adequate to carry out post-mortem inspection for all the goats and sheep slaughtered for the day. As such much attention was paid to cattle since they are bigger animals and their meat is consumed by most people in the metropolis. Similar observations were made at the Bolgatanga abattoir, Chereponi slaughterhouse and Bimbilla slaughterhouse where post-mortem meat inspection was only done on cattle. Inspection of carcass and offal should be carefully done in slaughterhouses to ensure that meat is safe and hygienic (Hajimohammed *et al.*, 2014). During joint meat inspection in the Bolga abattoir, Damongo slaughterhouse, Tamale abattoir, Wa slaughterhouse, Hamile slaughterhouse, Salaga slaughterhouse and Chereponi slaughterhouse the common diseases that were encountered were: tuberculosis, contagious bovine pleuropneumonia, fractures and body lesions. This is in agreement with findings of Lawan *et al*. (2013) who indicated the occurrence of diseases such as tuberculosis, hydatidosis and cysticercosis in north-western states of Nigeria.

5.6.9 Carcass and meat condemnation

From Table 4, four slaughterhouses (Tamale, Bole, Hamile and Salaga) representing 20% had rooms demarcated for condemning carcasses. This indicates that the rest of the slaughterhouses representing 80% do carcass condemnation within the slaughter halls were other slaughtering activities takes place.

With regards to observations on carcass condemnation, there was no complete carcass condemnation observed in all the slaughterhouses visited. However partial meat

condemnations were observed at the Tamale abattoir, Damongo slaughterhouse, Wa slaughterhouse, Salaga slaughterhouse, Hamile slaughterhouse, Tumu slaughterhouse and Bolgatanga abattoir. This contradicts the reports of Martinez *et al.* (2007) who indicated that in a Spanish abattoir, a total of 513 pig carcasses out of 6017 (8.5%) were rejected and condemned during meat inspection due to abscesses, cachexia, catarrhal bronchopneumonia, vertebral osteomyelitis, arthritis, pleuritis, peritonitis and pleuropneumonia. Roeber (2010) also reported that a dairy industry lost nearly $12 million due to cattle carcass condemnations. Alton *et al.* (2010) indicated that out of 1,162,410 processed cattle, from 2001-2007 in Canada, a total of 6875 carcasses were rejected for reasons of which septicaemia and/or toxaemia were typically the leading cause for the condemnations.

5.7 Transportation of carcass

After the carcass was inspected by veterinarians, it was then made ready for transportation. The main means of carcass transportation was a motorised tricycle commonly known as “motor king”. This agrees with the findings of Fearon *et al.* (2014) who reported that there is only one old, wretched meat van used to transport meat from the Tamale abattoir to the market. These necessitated butchers to convey their meat on bicycles, motorbikes and motorised tricycles popularly known as motor king as well as in the booths of taxis under very unhygienic conditions (Fearon *et al.*, (2014). This also agrees with the findings of Ofosu-Koranteng (2010) who mentioned that consumers used tricycles and taxis to convey the carcasses to their destination at the Tulaku slaughterhouse. Adzitey *et al.* (2011) and Abuska (2006) reported that the popular means of transporting raw beef carcass from the abattoir to sale points in the Bawku

Municipality and Garu-Tempane District respectively were through motor bikes, bicycles, push trucks, basins on butcher's head and on the hands and shoulders of butchers. However, butchers carried carcass and meat to the vehicles on their shoulders and heads with bare-hands. This agrees with the findings of Mummed and Webb (2015) who indicated that, at public abattoirs, workers transported carcasses from the conveyer bar to the vehicle on their shoulders in Ethiopia. Also, there was no meat or cold van used for carcass transportation in all the slaughterhouses visited at the time of this study. This is in agreement with the findings of Ofosu-Koranteng (2010) who reported that cold vans were not available at the Tulaku slaughterhouse to transport slaughtered animals to other markets. This practice could cause cross-contamination of carcass and pose serious health implications to consumers.

5.8 Waste management in the slaughterhouses

Waste which include both solid and liquid is something that needs proper management systems considering its effects on the health of man, the environment and life in general. Although described as waste because of its form at the point of generation, new techniques are developed to produce poultry by-products and reduce environmental problems (Mijinyawa and Dlamini, 2006). Slaughterhouses generate a lot of waste because of the activities they are engaged in. Water is used mainly, in the washing of carcass, equipments, the floors and walls of the interior part of the slaughterhouses more especially the slaughter areas. This makes the slaughterhouses generate a lot more liquid waste than solid waste. As such serious attention needs to be paid to its management by the appropriate bodies. Considering that waste from these facilities pollutes the environment, water bodies and its health implications on the individual, little was done

by the appropriate authorities on its management during this study. Some researchers reported that abattoir activities are responsible for the pollution of surface and underground waters as well as air quality which indirectly affect the health of residents living within the vicinity of abattoirs (Odoemelan and Ajunwa, 2008; Patra *et al.*, 2007).

During this study, it was observed that, none of the slaughterhouses visited were engaged in any effective waste management. Solid wastes were seen littered all over the surroundings of the slaughterhouses with scavenging animals such as dogs, pigs, vultures and free roaming chickens feeding on intestinal content and meat scraps on bones. This agrees with the observations of Murshidul *et al.* (2014) who reported that free-roaming dogs were present in all eight abattoirs, crows were present in five abattoirs and free-range chickens were present in a local abattoir in Bangladesh. Few slaughterhouses had 'zoom-lion' truck-bins with many of them filled to the brim with slaughter waste and rubbish. Children were seen defecating amidst the heaps of slaughter waste in the Bolgatanga and Salaga slaughterhouses. Fearon *et al.* (2014) reported that the abattoir waste materials are entirely organic that can be composed or recycled and used for various activities, yet they are left to degrade, producing bad stench. In other slaughterhouses, there were no dustbins and heaps of waste could be seen much closed to the facilities. In the Tamale abattoir, biogas plant was cited but it was not in used at the time of this study. Rabah *et al.* (2010) reported that although abattoir waste carries high levels of microbes that may be harmful to humans; they are an excellent substrate for generating biogas. According to management of the abattoir, both solid and liquid waste such as rumen contents, condemned carcass, blood and meat trimmings were channelled into the production of biogas to provide fuel for carcass singeing. This was a way of

preventing butchers from using old-car tyres for singeing carcasses in the abattoir, but the plant later developed a fault that they were still trying to fix before they could continue with the biogas production. It was observed that condemned carcasses were buried in slaughterhouses where condemnation occurs. Although none of the slaughterhouses visited were cited closed to dams, rivers or streams, there were bore-holes and wells in the surroundings. And these water sources could be polluted by the waste generated from the slaughterhouses.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Results from this study revealed that, majority of the slaughterhouses slaughter fewer number of animals due to lack of infrastructures and basic slaughter equipments. Therefore, slaughterers and butchers prefer the slaughterhouses upgraded and provided with modern slaughter equipment to increase their daily slaughter.

Concerning equipments and it effectiveness on meat production, it was concluded that none of the slaughterhouses had better equipment for effective meat production in the study areas. This could hamper its effectiveness on meat production and that much was needed to be done to improve upon the infrastructural systems in the slaughterhouses. It was also concluded that, the most acceptable observations were the materials the walls of the slaughterhouses were made up of, the roofing, the floor and the fact that enough ventilations were provided in all those facilities. Based on these factors, the slaughterhouses could be said to be partly in good conditions.

With regard to safety precautions, none of the workers (butchers, slaughterers and management staff) in all the slaughterhouses visited observed strictly safety rules and regulations during slaughter activities.

It was concluded that, sanitation in general was poor in all the slaughterhouses visited.

All slaughter operations except evisceration were concluded to be satisfactorily done. However, evisceration needed an improvement.

Concerning carcass and meat inspection, majority of the slaughterhouses had veterinarians doing both ante-mortem and post-mortem meat inspection. However, there were no enough meat inspectors and veterinarians in the slaughterhouse but meat inspection was on the average. Based on the slaughter procedures observed in all the slaughterhouses visited, it was therefore concluded that the slaughter practices were below standards.

With regards to waste management, there was no effective management systems in all the slaughterhouses visited. The common forms of waste disposal were dumping of rubbish into dustbins, by piling them into heaps, by burning them and by burying them. Wastes were poorly managed in the slaughterhouses in northern Ghana.

6.2 Recommendations

In line with the observations and conclusions, the following recommendations were made at the various sections of the slaughterhouses.

6.2.1 Recommendations on infrastructure of the slaughterhouses

- Government should construct slaughterhouses spacious enough to give enough room for more animals (cattle) to be slaughtered and processed for meat daily.
- Government should also equip the slaughterhouses with the necessary infrastructure and equipment to increase meat production in northern Ghana.

6.2.2 Recommendations on safety measures in the slaughterhouses

- Workers in the slaughterhouses should be educated by the appropriate authorities on safety rules and regulations and how to apply them on meat production.

- Also, safety wears and gadgets should be provided in the slaughterhouses by those in authority to help minimise accidents in the slaughterhouses.

6.2.3 Recommendations on slaughter practices

1. Restraint

   - Animals should be restraint with care and attention to avoid injuries during slaughter.

2. Stunning

   - Animals should be stunned before they are bled.

3. Bleeding

   - Animals should be bled on raised platforms to prevent them from picking germs from the floor.

4. Skinning

   - The process should be carried out on clean floors. Also, doing it on raised platforms will be more appropriate than on the bare floors.

5. Evisceration

   - The process must be carried out on elevated platforms to prevent direct contact of the carcass with the floor.
   - The process must be carried out with much attention to prevent punctures on the viscera. This will prevent the content of the viscera from soiling the rest of the carcass.

6. Carcass/meat inspection

- Strict enforcement of ante-mortem examination before slaughter by qualified veterinarians. This would reduce the slaughter of diseased animals.
- Research work should be done on microbial analysis of meat samples from the study areas.
- More meat inspectors and veterinarians should be recruited and send to all slaughterhouses and abattoirs in Ghana.

7. Carcass splitting

- The process should be carried out on raised platforms.
- Machetes and knives used for this process must always be sharpened and kept clean.

8. Carcass transportation

- Carcasses should be transported in enclosed vehicles.
- District Assemblies should provide cold vans to the slaughterhouses for safe meat transportation.

11. Waste management

- Dust bins must be provided in all the slaughterhouses. This will prevent the indiscriminate throwing of rubbish around the premises of the facilities.
- Provisions should be made to channel most of the waste generated from the facilities into biogas production.

- Educating workers at the slaughterhouses on the importance of proper slaughterhouse waste management and disposal will also ensure that most of the wastes will be properly handled and disposed without endangering the environment.

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Appendix 1

RESEARCH QUESTIONNAIRE

Topic: An assessment of slaughterhouses and slaughtering procedures in northern Ghana.

1. Name of region/town…….

2. Name of facility/slaughterhouse……

3. Location of facility……..… a) in the mist of human settlements, (b) near human settlements, (c) away from human settlements.

Assessment of the building of the facility

4. Do you see the size of the building to be sufficient for your daily slaughter?.....(a) yes (b)no

5. What is the walls of the building made of?.....(a) concrete and cement (b) bricks (c) mud (d) wood (e) zinc (f) wall tiles (g) others

6. What is the roof made of?.....(a) zinc (b) thatch (c) concrete roof (d) others

7. What is the floor made of?..... (a) concrete and cement (b) wood (c) un-floored (d) floor tiles (e) others

8. Are they windows/ openings to ensure effective ventilation in the facility?.....(a) yes (b) no

9. If yes what are the windows made of?.....(a) glass (b) metals (c) wood (d) others

Assessment of the environment of the facility

10. Is the environment floored……..(a) yes (b) no

11. If yes with what material?.....(a) concrete and cement (b) floor tiles (c) gravel (d) un-floored (e) others

12. Is the facility fenced……..(a) yes (b) no

13. If yes what is the fenced made of…….(a) blocks (b) wood (c) zinc (d) wire netting (e) others

14. Is there space available for the entry and exits of vehicles that come in to off load animals/ load meat to the market……..(a) yes (b) no

15. Is there a motorable road leading to the facility……(a) yes (b)no

16. Are there pavements to facilitate the easy movement of people in the facility …….(a) yes (b) no

17. Is there a parking space for vehicles especially for management…….....(a) yes (b) no

18. Does the facility have a meat van?.....(a) yes (b) no

19. If yes, is it in use?..... (a) yes (b) no

20. Is the facility having any source of power or electricity?.....(a) yes (b) no

21. Are there lairage(s) for temporal rest/ante-mortem inspection in the facility?.....(a) Yes (b) no

Assessment of safety/ wears of staff in the facility

22. Do you wear safety boots during operations in the facility…….....(a) yes (b) no

23. Do you wear apron during operations in the facility?..……..(a) yes (b) no

24. Do you wear gloves during operations in the facility…….(a) yes (b) no

25. Do you wear safety helmet during operations in the facility……....(a)yes (b) no

26. Do you wear goggles during operations in the facility……...(a) yes (b) no

27. Does the facility have fire extinguishers…….....(a) yes (b) no

28. If yes, are they functioning.……...…..(a) yes (b) no

29. Are they water hydrants around or near the facility?.....(a) yes (b) no

Assessment of equipments in the facility

30. Mention the various equipments used in dressing slaughtered animals in the facility……. ……..

31. Equipments for sticking/ severing……...

32. Equipments for dehairing/ flaying……...

33. Equipment for evisceration……..

34. Equipment for splitting meat into various sizes/ parts…….

35. Are there freezers or refrigerators to supplement cold rooms and chillers? …….....(a) yes (b) no

36. Does the facility have stunning equipments……...(a) yes (b) no

37. If yes are they functioning.…….(a) yes (b) no

38. Mention the type you have……..

39. Do you have slaughter machines in the facility for slaughter or slaughtering is done manually?.....(a) yes (b) no

40. Do you have shackles for hooking animals prior to slaughter or after slaughter?.....(a) yes (b) no

41. If yes are they in use?…….....(a) yes (b)no

42. Are they rails in the slaughter room in which slaughtered animals/meat are hanged to prevent it from touching the floor…….(a) yes (b) no

43. Does the facility have weighing scales?.....(a) yes (b) no

44. If yes, are they different types serving different purposes or just one……(a) different types (b) the same

Assessment of laboratories/ storage rooms in the facility

45. Does the facility have an isolation room/block for sick animals in the facility…….....(a) yes (b) no

46. Does the facility have a condemned room for rejected meat/ carcasses…….... (a) Yes (b) no

47. Does the facility have laboratories…….....(a) yes (b) no

48. Does the number of animals' increases or decreases as days go by……..? (a) Increases (b) decreases

49. Which animals do you slaughter the most……...(a) cattle (b) sheep (c) goat (d) pigs

50. Do you slaughter poultry in your facility?……...….(a) yes (b) no

51. Does the facility have storage rooms for keeping hides/ skin of killed animals……(a) yes (b) no

52. Does the facility have thermometers for checking the temperatures of carcasses/meat……..(a) yes (b) no

53. Does the facility have equipments that provide hot water for scalding small ruminants……(a) yes (b) no

54. Does the facility have cold rooms/ chillers to preserve meat…….(a) yes (b) no

55. Does the facility have equipments for singeing carcasses?.....(a) yes (b) no

56. What is the source of fuel use in singeing carcasses in your facility?.....(a) firewood (b) LPG gas (c) scrap tyres (d) biogas

57. Does the facility have special place for bleeding animals or is it done any where?.....(a) yes (b) no

Assessment of staff adequacy in the facility

58. Does the facility have adequate staff?.....(a) yes (b) no

59. If yes, are they adequate meat inspectors or veterinary officers doing day to day ante-mortem and post-mortem meat inspection in the facility?.....(a) yes (b) no

60. If no, what account for the deficiency?.....

Assessment of sanitary conditions in the slaughterhouse

61. Do you have knowledge on animal welfare?.....(a) yes (b) no

62. Do you have knowledge on sanitation in the slaughterhouse?…… (a) yes (b) no

63. How often do you clean/wash the floor of the slaughter area…….(a) daily (b) weekly (c) monthly (d) yearly

64. Do you wash/sterilize your equipments after usage?.....(a) yes (b) no

65. If yes with what……(a) hot water (b) chemicals (c) others

66. Do you control pests in the facility?.....(a) yes (b) no

67. How do you control them?.....(a) using pesticides (b) Using traps (c) others

68. How do you manage waste/trimmings from the facility……(a) burn them (b) burry them (c) use in biogas production (d) thrown away

69. Are they washrooms/ toilets in the facility……....(a) yes (b) no

70. If yes are they functioning?.....(a) yes (b) no

71. Are there drainage/ guttery systems in the facility?.....(a) yes (b) no

72. Are there bio-security measures put in place to check possible zoonotic diseases?.....(a) yes (b) no

73. If yes which type?.....(a) fence (b) footbath at the entrance (c) others.

74. Is there any source of water for the operation of the facility……..……...(a) yes (b) no

75. What is the source of the water?.....(a) dam (b) pipe-borne (c) well (d) borehole (e) others.

Others

76. Is this facility private or state owned?.....(a) private owned (b) state owned (c) others

77. Does this facility operate with a license?……..…….

78. On average, how many animals do you slaughter in a day?.....

Goat…….. Sheep…….. Cattle……swine……others……..

79. Where do you get your slaughter stock from?.....

Interacting with meat inspectors/veterinary officers in the facilities

Name of officer…….

80. How many veterinary officers are in this facility?……..

81. Do you do ant-mortem/post-mortem inspection in this unit?.....

82. Which common diseases do you encounter in carrying out your work as a meat inspector/veterinary officer in this unit…….....

……

83. What challenges do you face in performing your duty as a veterinary officer in this facility……

……
……

84. Have there been any in-service training organized by the district assembly for butchers on meat production in your outfit……

85. Have there been visits to the slaughter house by personnel from food and drugs board to ensure that butchers operates in line with their regulations……..

86. In your view, do you see this facility suitable for the production of meat meant for human consumption?.....

Assessment of slaughter houses based on animal slaughtering procedures

87. Do you stunned animals before slaughter in this facility?.....(a) yes (b) no

88. Does the facility have a bleeding section?……(a) yes (b) no

89. If yes, do you use it for bleeding purposes?.....(a) yes (b) no

90. Does the facility have a dehairing/skinning section?..……...(a) yes (b) no

91. If yes, do you use that section for skinning purposes?.....(a) yes (b) no

92. Does the facility have a scalding/flaying section?.....(a) yes (b) no

93. If yes, do you use it for the purposes?.....(a) yes (b) no

94. Does the facility have evisceration section?.....(a) yes (b) no

95. If yes, do you use it for evisceration purposes?.....(a) yes (b) no

96. Does the facility have a carcass splitting section?.....(a) yes (b) no

97. If yes, do you use that section for carcass splitting?.....(a) yes (b) no

98. Do you have knowledge on animal slaughtering procedures?.....(a) yes (b) no

99. If yes, please state the procedures involved…….

……
……
……
……
……

100. In your view do you think your meat production procedures follows the standards in meat production?……
……
……
……
……

Appendix 2

ANALYSIS OF THE INFLUENCE OF SIZE OF SLAUGHTERHOUSES ON NUMBER OF ANIMALS PROCESSED FOR MEAT DAILY.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.415[a]	4	.170
Likelihood Ratio	5.138	4	.273
N of Valid Cases	20		

a. 8 cells (80.0%) have expected count less than 5. The minimum expected count is .15.

SIZE OF BUILDING * NUMBER OF ANIMALS SLAUGHTER Crosstabulation

			NUMBER OF ANIMALS SLAUGHTER					Total
			1	2	3	4	6	
SIZE OF BUILDING	YES	Count	0	1	1	0	1	3
		Expected Count	.2	1.1	1.2	.5	.2	3.0
		% within SIZE OF BUILDING	0.0%	33.3%	33.3%	0.0%	33.3%	100.0%
		% within NUMBER OF ANIMALS SLAUGHTER	0.0%	14.3%	12.5%	0.0%	100.0%	15.0%
		% of Total	0.0%	5.0%	5.0%	0.0%	5.0%	15.0%
	NO	Count	1	6	7	3	0	17
		Expected Count	.9	6.0	6.8	2.6	.9	17.0
		% within SIZE OF BUILDING	5.9%	35.3%	41.2%	17.6%	0.0%	100.0%
		% within NUMBER OF ANIMALS SLAUGHTER	100.0%	85.7%	87.5%	100.0%	0.0%	85.0%
		% of Total	5.0%	30.0%	35.0%	15.0%	0.0%	85.0%
Total		Count	1	7	8	3	1	20
		Expected Count	1.0	7.0	8.0	3.0	1.0	20.0
		% within SIZE OF BUILDING	5.0%	35.0%	40.0%	15.0%	5.0%	100.0%
		% within NUMBER OF ANIMALS SLAUGHTER	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	5.0%	35.0%	40.0%	15.0%	5.0%	100.0%

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.566	.170
	Cramer's V	.566	.170
N of Valid Cases		20	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Appendix 3

A ceilingless roof at the Salaga slaughterhouse

Appendix 4

The state of the main entrance to the slaughter hall of the Tamale abattoir during slaughter activities