

UNIVERSITY OF GHANA, LEGON  
COLLEGE OF BASIC AND APPLIED SCIENCES  
ASSESSMENT OF THE CONSUMPTION TRENDS FOR GRASSCUTTER MEAT IN  
GA- WEST MUNICIPALITY AND DEVELOPMENT OF A THERMAL PROCESS  
SCHEDULE FOR CANNED MINCED GRASSCUTTER MEAT.



**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN  
PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF  
MPHIL FOOD SCIENCE DEGREE**

**JUNE, 2015**

**DECLARATION**

I, Titus Stanislaus Saanaakyaavuure Dery, hereby declare that the thesis herewith submitted for the degree M.Phil (Food Science) at the University of Ghana, Legon apart from the acknowledged references from other people's work, has not previously been submitted by me for a degree or diploma at another University or institution of higher education.

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## ACKNOWLEDGEMENTS

I wish to express my deepest gratitude and appreciation to the following individuals and offices within the University of Ghana who assisted in diverse ways towards the successful completion of this project. Dr. Niilante Amissah of the Department of Family and Consumer Sciences for his immense financial support, scientific advice and guidance, constructive criticism and research wisdom offered this project. Dr. Amissah, many thanks to you for being available anytime I called on you. Professor Firibu K. Saalia of the Department of Nutrition and Food Science for his statistical insights in the data analysis phase of this project, his guidance and scientific knowledge offered this project. I am indeed very thankful to you. Dr. Samuel Ohene-Adjei of the Department of Animal Science for his never relenting guidance and the deep research knowledge he offered to the realization of the objectives of the project. I am also grateful to the Office for Research, Innovation and Development (ORID) of University of Ghana for the research grant that funded this project. My sincere thanks also go to the Staff of the Cameron Meat Laboratory of the Animal Science Department for technical assistance with processing the grasscutter meat prior to canning. I am also grateful to the Staff of the Joana Nsarko Foods Laboratory of the Department of Family and Consumer Sciences for their immense support and encouragement. My sincere thanks also go to Rahinatu Aduni, Crossby Osei Tutu Junior, Akpabli-Tsigbe Nelson D. K. and Nana Kwame Owusu-Brafi for their assistance in the laboratory work. To my entire family and all loved ones, I say thank you for the diverse support you gave me toward the completion of this work. God richly bless all of you.

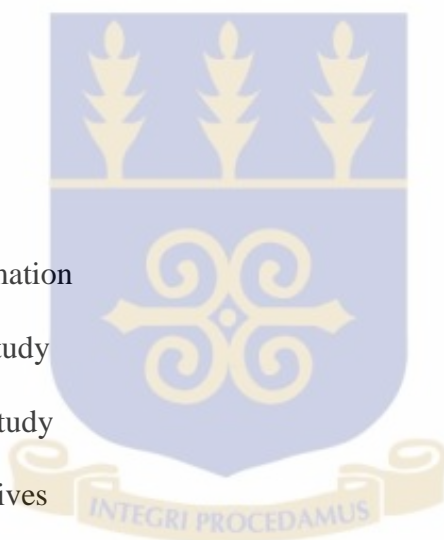
## **DEDICATION**

I dedicate this thesis to God and my family.



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**LIST OF ABBREVIATIONS**

BHT	Butylated Hydroxytoluene
GIT	Gastrointestinal Tract
GSS	Ghana Statistical Service
GTZ/SFSP	German Technical Co-operation Sedentary Systems Project
HPLC	High performance Liquid Chromatography
HPP	High Pressure Processing
JICA	Japanese International Corporation Agency
LP	Lipid Peroxidation
MAP	Modified Atmosphere Packaging
MDA	Malondialdehydes
MDGs	Millennium Development Goals
MoFA	Ministry of Food and Agriculture
MSI	Mineral Safety Index
NGO's	Non-governmental Organizations
NRC	National Research Council
NTFP	Non-Timber Forest products
NWFP	Non-Wood Forest Products
ORID	Office for Research, Innovation and Development
PPEA	Projet Promotion de l'Eleavage d'Aulacodes
PUFA	Polyunsaturated Fatty Acid
RDA	Recommended Dietary Allowance
RTE	Ready To Eat
SFA	Saturated Fatty Acid
SPSS	Statistical Package for Social Sciences

TBA	Thiobarbituric acid
TBARS	Thiobarbituric Reactive Substances
TDT	Thermal Death Time
TDTM	Thermal Death Time Model
TEP	Tetraethoxypropane
TPA	Texture Profile Analysis
VSF	Vétérinaires Sans Frontieres
ZSL	Zoological Society of London

## ABSTRACT

The objectives of this study were to assess the consumption trends of grasscutter meat among consumers in Ga-West Municipality, to determine the thermal process parameters (cooking time and sterilization temperature, i.e  $F_0$  values) of canned minced grasscutter meat, to evaluate consumer acceptability of canned minced grasscutter meat and to assess the quality changes of canned minced grasscutter meat during storage. A cross sectional survey was conducted to establish the consumption trends for grasscutter meat and the buying habits of patrons of food establishments in three of the six zonal councils of the Ga-West Municipality in Accra. A structured questionnaire was used to collect information on the demand characteristics and acceptance of canned grasscutter. The survey data showed that age, marital status and number of dependents of the respondents have significant associations with the preferred methods of preparing and cooking grasscutter meat, the frequency of consumption, cost of grasscutter meat, availability of the meat, and preference for grasscutter meat ( $p \leq 0.05$ ). Specifically, respondents who were between thirty one (31) to forty (40) years, married and had more than two dependents preferred smoked grasscutter to boiled, grilled, dried and fried grasscutter meat. Respondents who were single and those with two dependents frequently ate grasscutter meat. Cost of grasscutter meat limited consumption by married respondents. Though grasscutter meat is in high demand, 57% of respondents would not accept a canned grasscutter product because of possible increase in the cost of the meat. A thermal process was used to develop canned minced grasscutter on a  $3 \times 3$  factorial design. Sterility of canned minced grasscutter meat was achieved ( $F_0 = 9.42$ ) at minimum time of fifteen minutes at  $121.1^\circ\text{C}$  which is higher than commercial target  $F_0$  of 3.0 for the inactivation of *Clostridium botulinum* spores. In complete sterilization occurred at temperatures below  $116^\circ\text{C}$  for 15, 20, 25, 30 and 45 minutes. Canned minced grasscutter meat was acceptable

to consumers. There were high scores for texture, colour and juiciness for canned minced grasscutter meat. Panelists however neither liked nor disliked the aroma and flavour of the product. Canned minced grasscutter maintained its sensory qualities during six weeks storage at room temperature. Accumulation of Thiobarbituric Reactive Substances (TBARS) in stored canned minced grasscutter meat samples was also minimal during the storage period. The study established a thermal process schedule for canned minced grasscutter meat.

**Key words:** Canning, Grasscutter meat, TBARS, Colour, Drained weight

## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background information

Wildlife has been an important protein source for many West African countries over centuries. The population of these animals (duikers, red Columbus monkeys, chimpanzees and grasscutter) are now dwindling and are inadequate to provide the protein needs of the people of West Africa due to over dependence over the past years (Cimino, 2009; Hoffman *et al.*, 1999). Currently the West African wildlife stock is getting scarce as a result of indiscriminate hunting practices with little attention to the species, sex and age of wildlife which are important meat sources that cannot be replaced by others in the years ahead (Hoffman *et al.*, 1999). Many governments, non-governmental organizations (NGOs) and business interest have started promoting animal rearing to curtail the problems associated with the depletion of wildlife and protein deficiency. Livestock and associated products make up more than 50% of the total value of gross agricultural production in developed countries but only one-third of this figure is realized in developing countries (Cimino, 2009).

In Ghana, eleven bush animals are eaten as sources of food (Ntiamo-Baidu, 1997). Ten of these animals are pests on cocoyam, cassava and maize farms and constitute 80% of all bush meat sold in Ghanaian markets and restaurants (Atmadja, 2004). Rodents are the most preferred and commonly consumed bush animals and remain as the main source of protein for developing countries (Lynwood, 1990; Assogbadjo *et al.*, 2005). More than eighty nine (89) rodent genera are eaten by man. Most families and species of rodents are hystricomorphs which are normally bigger, tastier, easier to catch and mostly vegetarian. Thirty six (36) rodent species are eaten in Africa while Latin America and the Caribbean consume over twenty four rodent species all belonging to hystricomorphs (Lynwood,

1990). Between one and five million metric tonnes of bush meat is harvested worldwide each year (Clarke, 2003). Unfortunately, these wild animals are less recognized in national programmes for human food security (Assogbadjo *et al.*, 2005).

Rural dwellers depend mostly on bush meat as an economic and protein source for livelihood (Abernethy, 2011). The consumption of protein in the right amounts and the role it plays in nutrition is well documented (Onyeanusi *et al.*, 2008). Ghana and Nigeria are well-known for their consumption of bush meat. More than 80% of Ghanaians in both rural and urban areas prefer bush meat and would eat it if available. Bushmeat is popular and important in most traditional festivities among African communities (Blankson-Arthur *et al.*, 2011) and among the wild animals is the grasscutter which has gained wider interest among African countries (National Research Council, 1991) including Ghana. The meat is widely consumed in Ghana (Annor and Kusi, 2008; National Research Council, 1991). Grasscutter is one of the Non-wood Forest Products (NWFP) in Ghana, and is found in two-thirds of the savannah vegetation in Ghana (Osei-Tutu *et al.*, 2010). Grasscutter makes up the predominant bush meat consumed in African countries (Odebode *et al.*, 2011; Odebode *et al.*, 2012). Although Non-Timber Forest Products (NTFP) such as grasscutter, snails, honey, medicinal plants and mushrooms are essential commercial products, not much information is known about their collection, processing, utilization and packaging/labeling requirements in Ghana and the international market. Their contribution to the economy, society and the environment has not been given much attention both in value and in research (Ahenkan and Boon, 2010). Grasscutter farming is common nowadays and it is farmed as a micro-livestock species in many African countries (Opara and Fagbemi, 2008). The meat is eaten locally and it is also exported for income among countries in West Africa (Asibey, 1969; National Research Council, 1991). The meat is

eaten by all social classes in both rural and urban settings (Onyeanusi *et al.*, 2008; Odebode *et al.*, 2011; Owen and Dike, 2012; Etchu *et al.*, 2012).

Processing and preservation methods for grasscutter meat are not well advanced in literature. The meat is sold either fresh or smoked. The available literature focuses on the traditional smoking method. The methods used in processing grasscutter meat are flaming and scalding. Flaming involves the use of fire from fire wood to remove the fur, while scalding involves dipping the animal in hot water to ease the removal of the fur. Many consumers prefer flamed grasscutter meat to scalded grasscutter meat as the flamed meat is perceived to have better flavour than scalded grasscutter meat (Omole *et al.*, 2005; Ahenkan and Boon, 2010). Neither flaming nor scalding has a significant effect on the weight of the organs, dressing percentage, flavour, chemical composition and general acceptability of grasscutter meat hence, consumers can use any of the two methods for removing the fur of grasscutter (Omole, *et al.*, 2005).

Most hunters sell grasscutter in the raw form in local markets and on highways though the processed form has better prices. Despite the awareness of the huge international market for grasscutter, lack of processing and packaging skills and facilities are bottlenecks (Ahenkan and Boon, 2010). No formal training on hygiene and handling practices of the processed meat is given to the handlers and this can potentially create a negative impression about the grasscutter industry in Ghana (Heloo, 2005). In Ghana, individuals who process grasscutter meat sell the meat by the road side with adverse health implications for consumers of these processed products. The largest road side bushmeat market where grasscutter is dominant is at Anyinam in the Eastern Region of Ghana due to its proximity to Atewa forest which has the highest moist evergreen patches and biodiversity conservation of floral and faunal species including grasscutter in Ghana

(McCullough *et al.*, 2007). In Southern Nigeria grasscutter is one of the most sold and consumed bushmeat (Martin, 1983).

## **1.2 Rationale for the study**

There is an increased demand for grasscutter meat in Ghana (National Research Council, 1991; Annor and Kusi, 2008) and patronage for grasscutter meat consumption is generally high in sub-Saharan Africa (Opara and Fagbemi, 2010). About forty thousand (40,000) tonnes of grasscutter meat is eaten annually in West Africa (Mensah *et al.*, 2005). Consumer needs for both fresh and smoked grasscutter meat is unmet (Odebode *et al.*, 2011). The incessant African population growth rate with the lowest protein supply in the world (Opara, 2010), calls for more attention to the regular supply of grasscutter meat as a possible alternative to pork, chevon, beef and chicken since there are no religious prohibitions for the consumption of grasscutter meat (Odebode *et al.*, 2011; Etchu *et al.*, 2012).

In many rural areas of Ghana, households rear goats, poultry, cows and sheep but these are normally consumed during special festivities (Odebode *et al.*, 2011). The occasional consumption of meat could be one of the causes for protein shortage in Africa. Grasscutter is a prolific breeder, rich in protein (Asibey, 1978) and the widespread acceptance of the tasty meat may help solve the shortage of animal protein especially in Africa if the meat is processed and made available all year round through value addition. Smoked grasscutter meat does not provide the consumer with a portable convenient product that is, ready-to-eat (RTE) or easy to prepare and consume. Available canned animal products in the Ghanaian markets include those from cattle, sheep, pigs, poultry and goats while no attention is given to similar products from grasscutter meat. Grasscutter industry can

provide economic value through international trade, regional and continental preference for the meat (Opara, 2010).

In Africa, there is an opportunity to process grasscutter meat into value added products and sell it to consumers, especially in West African countries like Ghana, Benin and Nigeria where demand keeps surging all the time. Globally, consumer eating patterns are shifting from laborious food preparation to ready to eat (RTE) processed foods. In Ghana, most processed foods that are available in the markets include instant fufu flour, canned palm fruit extract, instant porridge flour, banku flour, tomato paste concentrates, soybean oil, canned fruit juices, fish, meat and meat products. Ghana, Nigeria, Zambia and South Africa have data on the quality and carcass characterizations of grasscutter meat but no attempt has been made to process grasscutter meat by canning. This work therefore seeks to develop appropriate processing parameters for canning grasscutter meat for both local and international consumption.

### **1.3 Objectives of the study**

The general objectives of this work were to assess consumer demand for grasscutter meat and to develop a thermal process schedule for canned minced grasscutter meat to provide a convenient ready-to-eat product.

#### **1.3.1 Specific objectives**

- i. To assess the consumption trends of grasscutter meat among consumers in the Ga-West Municipality of the Greater Accra Region of Ghana.
- ii. To determine the thermal process parameters (cooking time and sterilization temperature, i.e  $F_0$  values) of canned minced grasscutter meat.
- iii. To evaluate consumer acceptability of canned minced grasscutter meat

- iv. To assess the quality changes of canned minced grasscutter meat during storage.

## CHAPTER TWO

### 2.0 LITERATURE REVIEW

#### 2.1 Grasscutter

Grasscutter is a wild mammalian rodent of the family thryonomyidae (Wood, 1974). *Thryonomys swinderianus* and *Thryonomys gregorianus* are the two species that exist (Rosevear, 1969; Simpson, 1974). *Hystricomorpha* is the sub species of *swinderianus* (Wood, 1974). The commonest species is the *Thryonomys swinderianus*. It looks more like the porcupine than a rat and lives in grassy and wet lands in Africa. Grasscutter is the second largest wild rodent after the porcupine in Africa (Wood, 1974). The legs are short with five digits on the forefeet and four digits on the hind feet. The claws are thick and the incisors are orange in colour adapted to feed on the toughest vegetation (Okorafor *et al.*, 2012). The grasscutter has round ears, coarse bristle fur and a short nose. The hind limbs are longer than the fore limbs and these support the weight on the ground (Adeyeye and Jegede, 2010). Both common species (*Thryonomys swinderianus* and *Thryonomys gregorianus*) have firm, bristle fur with yellow-brown to gray-brown bodies with whitish bellies and look like suckling pigs. The round nose, spiny fur and short-scaly-sparse hairy tail differentiate it from the true rat (National Research Council, 1991). *Thryonomys swinderianus* is up to 60 cm long, weighs up to 9 Kg with 65% dressing excluding the offals (Odebode *et al.*, 2011).

Grasscutter has more yield meat than traditional livestock and a better nutritive profile compared with other meats such as chevon, beef, mutton and chicken. Crude protein content of grasscutter is about 22.7% compared with 20.7% for rabbit, 19.25% for chicken and 18.2% for beef and has less fat and cholesterol than beef, mutton and pork (Omole *et al.*, 2005).

## 2.2 Nutritional composition of grasscutter meat

Adeyeye *et al.* (2012) analyzed the lipid profile of the skin, muscle and liver of *Thryonomys swinderianus* and found that all of them contained good polyunsaturated fatty acids (PUFA). The study also showed that the ratio of PUFA to the saturated fatty acids (SFA) was higher than the minimum recommended value of 0.45. PUFA/SFA values were 0.86 for skin, 1.26 for muscle and 1.07 for liver. The meat of grasscutter contains 22% protein and 4% fat, (Louw, 2008). Adeyeye and Jegede (2010) found out that high levels of both essential and non-essential amino acids are in the meat of *Thryonomys swinderianus*. They also found out in the same study that most of the protein in grasscutter is located in the limb muscles with the skin having the lowest crude protein value but containing the highest value of carbohydrates followed by the liver and muscle while the brain contains more fat than the skin, muscle and liver.

In further analysis, Oyarekua and Ketiku (2010) found out that the phosphorus level in the limb muscle (750 mg/100 g) is comparable to the Mineral Safety Index (MSI). Phosphorus, Zinc and Iron in the liver were higher than the MSI while calcium and magnesium were lower than the MSI. There were also higher values of phosphorus, zinc and iron in the brain and comparable values of magnesium and calcium. The skin has higher value of iron than the MSI level, lower values of magnesium, zinc and calcium but comparable value in phosphorus. Phospholipids are emulsifiers and take part in the digestion of fat in the intestine and it was higher in the liver than the skin (Adeyeye *et al.*, 2012) probably due to the fact that they are stored in the liver (Oyarekua and Ketiku, 2010). The monoglycerols level increases respectively in the skin, brain and liver while none was recorded in the muscle. Diacylglycerol was not found in the brain, low in the liver and comparable in the skin and muscle. All parts of grasscutter were comparable with the Recommended Dietary Allowance (RDA) of cholesterol (45 - 75 mg/day). Iron level

in the grasscutter was higher than the recommended 8 mg/day for males and 18 mg/day for females, while all samples had lower calcium levels than the recommended 800 - 1200 mg/day (Oyarekua and Ketiku, 2010).

### **2.3 Market value for grasscutter meat**

The true economic value, social and environmental significance of NTFPs in alleviating poverty is difficult to estimate as marketing of these products are primarily done individually in an unorganized and dispersed manner and these marketers lack the necessary marketing skills and information to access leverage in the market (Ahenkan and Boon, 2010). Prices for these products depend on the proximity to buyers, length of the supply chain, seasonal variation of the species and market demands (Cowlshaw *et al.*, 2004).

Bushmeat which is valued at 350 million US dollars of which 83 million US dollars is sold commercially, is a vital source of income for the people of West Africa (Mendelson *et al.*, 2003). Many different actor groups are involved in the bushmeat trade. These actor groups are the farmer hunters, commercial hunters, wholesalers, market traders and chop bar operators. The hunters groups are all men while the rest are females (Cowlshaw *et al.*, 2004; Ahenkan and Boon, 2010). In Ghana, bushmeat trade is governed by the Wild Animal Preservation Act (Act 43) (Lindsey *et al.*, 2013). This Act classifies species protected from hunting and the length of protection by age (young/adult) and period (all year round/closed season only). It is however known that the knowledge on the legislation on hunting by all these actors is minimal (Lindsey *et al.*, 2013). Many driving factors contribute to the hunting of bushmeat among African countries. These drivers are complex and varied and include poverty and food insecurity, increasing human encroachment of

wildlife areas, lack of clear rights over wildlife or land and increasing demand for bushmeat (Cowlshaw *et al.*, 2004).

The grasscutter has a higher market price in Ghana compared with other bushmeat (Elango, 2007). Swensson (2005) identified that grasscutter was the most common hunted wild rodent on sale in Techiman central market in Ghana, West Africa. It was also found out in the same study that most of the grasscutter traded in the Techiman central market were smoked while those traded by wholesalers and chop bars operators were fresh. Two reasons identified for smoking grasscutter were for preservation of the meat and its superior taste compared with fresh meat. In a similar study by Cowlshaw *et al.* (2004), grasscutter was the most common bushmeat traded in the Takoradi market in Ghana, West Africa. Grasscutter is the most expensive meat in West Africa, selling at a higher price per kilogram than beef, chicken, pork and mutton (National Research Council, 1991).

### **2.3.1 Demand and consumption patterns for grasscutter meat**

Grasscutter meat is in high demand for meat in Central and West Africa. About eighty million (80 million) grasscutter are hunted for meat every year in West Africa which is equivalent to three hundred thousand (300,000) metric tonnes of meat (Louw, 2008). The demand for grasscutter meat is high because its consumption has no religious, sex, age and ethnic barrier. In Ghana, it is the most consumed bushmeat (Boateng, 2005). Demand for wild grasscutter has waned while preference for the domesticated species continues to grow as rural areas continue to urbanize (Kinsella, 2012).

## **2.4 Domestication of grasscutter in Ghana**

Grasscutter domestication first started in Ghana as early as 1960 by Sefa Asante who had 200 animals with 60 young grasscutters as of 2005 and Omari who had 1,500 animals as of 2005 (Mack *et al.*, 2005). Grasscutter rearing has reduced the problem of hunting wild grasscutter using bushfires and has minimized the risks to hunters who could be killed by wild animals or arrested by a forester. Rearing grasscutter is a source of revenue, making grasscutter more available as wild grasscutter is becoming scarce (Raouffou, 2005).

Breeding grasscutter enables the sustainability of wildlife and provides frequent income, ensures food security hence, breaking the vicious circle of poverty (Bakker, 2005).

Martin (1983) indicated in a study in Southern Nigeria that grasscutter was the most preferred species for domestication. The wide acceptability, excellent taste, high value of meat, high disease resistance, low capital inputs, low noise and relatively high meat yield of grasscutter compared with other animal species are some of the reasons most people rear grasscutter (Onyeanusi *et al.*, 2008). Contrary to this preference for grasscutter rearing was a report by Kinsella (2012) that many farmers in Brong-Ahafo Region in Ghana prefer rearing handy animals such as goats, sheep and pigs than grasscutter which require intensive management practices.

## **2.5 Grasscutter as micro-livestock**

Micro, small and medium enterprises are significant in the economic growth of developing countries. They contribute to jobs in society through innovations and creativity and help in human resource development. Income generation and poverty alleviation are the immediate and long term benefits (Agyapong, 2010). Policies for promoting the production, harvesting, processing and marketing of NTFP will improve food security, poverty alleviation and better the lives of Ghanaians (Ahenkan and Boon, 2010). Mini-

livestock production will potentially improve household animal protein consumption and provide income. These mini-livestock animals can easily be handled by women and children. Encouraging the production of this group of animals through various strategies such as promotional programmes and enlightenment campaigns by both government and non-governmental organizations is a necessity (Barwa, 2009).

Big animals such as cows, goats, sheep and pigs are difficult to rear due to limited available land, diseases and cost of production. For instance, rearing cows is limited by hazards such as infection by trypanosomiasis. In these situations inherently smaller animals such as rodents can serve as a major means of protein supply in many African countries. The grasscutter as a prolific breeder is caught and eaten or sold in markets and along roadsides. The trade in grasscutter meat is so large that Boateng (2005) reported that 73 tonnes of grasscutter meat was sold in one local market in Accra, Ghana representing 15,000 animals. The government, NGOs and donor institutions need to support Ghanaians who wish to rear this lucrative animal in order to achieve the Millennium Development Goals (MDGs) for growth and poverty alleviation (Boateng, 2005).

### **2.5.1 Role of the government of Ghana in grasscutter production**

The Ministry of Food and Agriculture (MoFA) in 1994, under the National Livestock Services Project started breeding grasscutter since it requires little capital and can be reared by everybody. The Animal Production Directorate of MoFA encourages grasscutter production to promote food security, employment, income, solve the animal protein deficiency and to reduce poverty in the country. The government of Ghana through MoFA established a domestication and breeding centre at the Nungua Livestock Breeding Farm for supply of breeding animals to farmers. MoFA has trained personnel throughout the country to promote grasscutter production and Women in Agricultural Development under

the Ministry trains people in grasscutter meat processing. The District Assemblies have been encouraged to use part of their Poverty Alleviation Funds to support grasscutter farmers (Ankrah, 2005). Grasscutter can survive well in degraded environments and breeding these animals could reduce the pressure of hunting in the bush (Bowen-Jones *et al.*, 2002).

### **2.5.2 Role of NGO's in grasscutter production in Ghana**

The 'Projet Promotion de l'Elevage d'Aulacodes' (PPEA), set up in Benin researched into grasscutter production in 1983. In 1994, animals were placed in pilot farms. Farmers were trained and later on became advisors to other farmers. This project was supported by ZSL (Zoological Society of London). VSF (Vétérinaires Sans Frontieres) started a trial project in Gabon, where grasscutter proved to be the most successful species from 1994-2000 (Evans *et al.*, 2011). Forty women in Ghana have been supported with breeding stock which subsequently provided them with protein and income for the family. The German Technical Co-operation Sedentary Systems Project (GTZ/SFSP) together with the Animal Production Unit of the Ministry of Food and Agriculture (MoFA) started grasscutter breeding in 2000 in the Brong-Ahafo Region of Ghana where feed was readily available (Yeboah, 2009). Heifer International and Japanese International Corporation Agency (JICA) have promoted grasscutter domestication in Ghana with the latter establishing grasscutter farms and expanding it to more than 54 communities in the Upper West Region of Ghana.

### **2.6 Constraints to grasscutter production in West Africa**

Farmers who wish to go into grasscutter production often lack the skills in production and knowledge in value chain addition for a successful venture (Heloo, 2005; Ahenkan and

Boon, 2010; Okorafor *et al.*, 2012) and diseases, start-up capital, easy access to stock and the scarcity of feed militate grasscutter production (Heloo, 2005; Okorafor *et al.*, 2012).

### **2.6.1 Common diseases associated with grasscutter**

Opara and Fagbemi (2008) and Futagbi *et al.* (2010) conducted studies on infectious diseases of grasscutter in the wild. Both studies reported very high prevalence of Gastrointestinal Tract (GIT) helminthes parasites infections of wild grasscutter. Opare, (2010) conducted a study on infectious diseases of captive grasscutters and found out that 17% of captive grasscutter were lost through diseases including abscesses, pneumonia and cardio-splenic dilation. Opara and Fagbemi (2010) revealed that grasscutter is a host to trypanosomiasis which can cause leucopenia and also decrease the immunity of the grasscutter leading to other infections and death. Three farms that were studied in Nigeria revealed worms infestation of all the grasscutter with high prevalence of *Ascaris* species. Some of the Nematodes were *Ascaris* sp., *Bunostomum* sp., *Strongyloides* sp., *Trichostrongylus* sp., *Oesophagostomum* sp., *Trichuris* sp., *Haemonchus* sp., *Nematodirus* sp, and *Strongyles* sp. The Cestode identified was *Taenia* sp, while *Eimeira oocyst* was the only protozoan parasite isolated (Olayemi, 2011).

### **2.6.2 Agricultural residues in grasscutter**

In a study conducted by Blankson-Arthur *et al.* (2011) in Ghana to find out the levels of organochlorine pesticide residues in grasscutter (*Thryonomys swinderianus*) tissues, it was found out that residues of dieldrin, aldrin, endrin, endrin aldehyde, endrin ketone, alpha-endosulfan sulfate, chlordane, heptachlor, methoxychlor, p, p-DDT and p, p-DDE occurred at very low concentrations in the muscles, liver and kidneys. These residues increased respectively in the kidney, liver and muscle samples analyzed. The authors

postulated past use of these agricultural residues in farming which accumulated in crops and the soil to be the source of accumulation in the grasscutter. However, all the organochlorine residues found in all the samples were below the FAO/WHO Codex Alimentarius (2005) maximum residue limits in that grasscutter meat is safe and healthier for consumption.

## **2.7 Geographical distribution and habitats of grasscutter**

*Thryonomys swinderianus* is mostly found in the Southern part of the Sahara Dessert of Africa and dwells in grassland, along river beds and among food crops and the forest zones (National Research Council, 1991; Adeyeye and Jegede, 2010). Adequate and desirable grass species available for food influences their geographical distribution. *Thryonomys swinderianus* typically inhabits the East, West and Southern parts of Africa. *Thryonomys gregorianus* is distributed in the savannas in Zaire, Sudan, Ethiopia, Kenya, Zambia, Uganda, Malawi, Mozambique, Zimbabwe, Cameroon and Central African Republic (National Research Council, 1991).

## **2.8 Live weight and length of grasscutter**

The live weight of grasscutter varies according to species, sex and age. In a study conducted by Odebode *et al.* (2011), the most common species in West Africa are *Thryonomys swinderianus* and *Thryonomys gregorianus*. *Thryonomys gregorianus* is about 50 cm long and weighs up to about 8 Kg while *Thryonomys swinderianus* is about 61 cm long and weighs about 9 kg (Adeyeye and Jegede, 2010; Odebode *et al.*, 2011). Grasscutter has carcass yield of about 64%, (Omole *et al.*, 2005; Louw, 2008; Odebode *et al.*, 2011).

## 2.9 Hunting wild grasscutter

Nasi *et al.* (2008) defined hunting as the collection of any wild species from the forest for specific purposes. Historically, hunting in Africa is primarily to feed the family. Until the days of colonial rule, hunting wildlife species were regulated by laws, privileges and restrictions aimed at conserving the ecological forests in Africa. These rules and restrictions were broken decades ago making hunting more rampant and deleterious to wildlife existence. The creation of market routes for bushmeat commercialization has also shifted subsistence hunting into a market oriented business. Reintroduction of hunting laws has not been successful after colonialism and restrictions that were placed on hunting during the period have received little success. Many governments have also failed to enact, implement and enforce hunting legislations but most often than not accuse traditional hunters of poaching (Caspary, 1999). Bushmeat is hunted mainly for subsistence, trade, sports, recreational, cultural and pest control (Bowen-Jones *et al.*, 2002). However, hunting wild animal is primarily for food and trade (Bowen-Jones *et al.*, 2002; Nasi *et al.*, 2008). In Ghana, hunting is normally done for trade (Cowlshaw *et al.*, 2004) or for both trade and subsistence (Hoffman *et al.*, 1999).

There is massive hunting for grasscutter (National Research Council, 1991). Hunting practices identified by the work of Swensson (2005) were shooting the animal with a gun (93%), trapping the animal (2%) and using poison made of mixture of salt, dried fish and sleeping pills (5%). Spears, dogs and fire can also be used to hunt grasscutter (National Research Council, 1991). The closed season for hunting is between 1<sup>st</sup> August, to 1<sup>st</sup> December every year (Boateng, 2005).

Assogbadjo *et al.* (2005) indicated that hunting practices differ with respect to the kind of animal, vegetation and season. The use of bushfire during dry season is the most common

hunting technique including chasing and trapping. Hoes are used to dig and catch grasscutter in their holes. Mostly, the hunters move in groups with dogs and hunt between 6:00 am to 12:00 pm in the morning and 3:00 pm to 6:00 pm in the evening.

Okorafor *et al.* (2012) found out that grasscutter hunting occurs every day with numbers hunted for each day dependent upon seasonal variations such as rain, drought, harmattan and moonlight. Generally, high numbers are caught in the dry season than in rainy season and during moonlit days.

## **2.10 Meat preservation methods**

Food preservation is the processing of food in order to extend its shelf life (Mass-Van *et al.*, 2004). Fresh meat is a highly perishable material due to its biological composition. Some of the frequently investigated non-thermal destruction of spoilage food pathogens include modified atmosphere packaging (MAP), bio preservation, use of antimicrobial compounds such as smoke, nitrites and nitrates and hydrostatic pressure (Zhou *et al.*, 2010). Other available preservation methods include freezing, drying, fermentation and heat sterilization. The use of milder preservation methods have been the main focus for food manufacturers due the increasing need for consumers' preference for food manufactured without chemical additives (Smid and Gorris, 2007).

### **2.10.1 Traditional meat preservation**

Meat is preserved to transport it over long distances without spoilage (Nychas *et al.*, 2008). Traditionally, bushmeat is preserved in Ghana by smoking, drying, fermentation and salting (Pace *et al.*, 1989). Smoking is the most common method that is used in preserving bushmeat in Ghana (Swensson, 2005). Though smoked bushmeat was most preferred by consumers in a study conducted by Swensson (2005) in the Techiman

markets in Ghana, poor heat control during smoking can make smoked meat bitter in taste. Low scores for smoked snails sampled in some selected Ghanaian markets have been reported to due to their bitter taste (Tettey *et al.*, 1997).

### **2.10.2 Modern meat preservation methods**

Barbosa-Canovas *et al.* (1997) stated some improved methods of food processing which target greater food safety and quality. These methods include high pressure processing, pulsed electric field, pulsed X-ray or ultra-violet light, Ohmic heating, radio frequency, microwave, pulsed light and oscillating magnetic fields. In the work of Zhou *et al.* (2010) modern methods of meat preservations were broadly categorized into controlling atmosphere, controlling water activity and the use of chemicals or bio preservatives.

During MAP of meat products, moisture and gas entering into packaging material are restricted by the use of an inert gas such as Nitrogen. This method is more effective when used in combination with antimicrobial substances. These antimicrobial substances prevent the growth of bacteria spores on the food surface thereby extending its keeping quality (McMillin, 2008). During Active packaging, the packaging material is intentionally altered at a fixed time through passive or active means (Yanyun *et al.*, 1994).

### **2.11 Thermal processing of meat**

The shelf life of food products can be extended through thermal processing. During thermal processing, the food product is heated at high temperatures for a short time and it is the basis for commercial sterilization of food products. The heat treatment of food products however depend on the specific objectives of the thermal heat processing and the product composition (Stoforos, 1995).

Optimal processing parameters especially on temperature fundamentally depend on factors such as the coefficient of heat penetration, and the size of the cans used in the canning process (Marra and Romano, 2003). For thermally processed products to attain their sensory qualities and economic value, it is necessary to determine the degree of sterilization of the final products without necessarily compromising quality and the economic value of the product (Carciofi *et al.*, 2002). Adamczak *et al.* (2006) found out that the degree of heat penetration is affected by the fat content of pork. The study showed that high fat in pork has high doses of heat penetration regardless of the size, shape and the particulate nature of the meat. That is both cut pieces and comminuted meat with high fat significantly affect heat penetration.

### **2.11.1 Heat-sterilizable containers**

Only containers that resist excessive temperatures should be used for thermal processing at retort temperatures. Some of these include metal cans, glass jars or bottles, flexible pouches and rigid trays (Krumm *et al.*, 1998). Each of these containers filled with the food to be processed should be exhausted before processing. Exhaustion is done to remove air and therefore reduce strain on the containers due to expansion and also prevents internal corrosion of containers (Juliano *et al.*, 2006). Steam therefore replaces the air and creates a partial vacuum after cooling the processed food. Exhaustion can be done in several ways some of which include: hot filling the food into the container (commonly used as it also pre-heats food which reduces processing times), cold filling the food and then heating the container and contents to 80 – 95 °C with the lid partially sealed (clinched), mechanical removal of the air using a vacuum pump steam flow closing, where a blast of steam (at 34 –  $41.5 \times 10^3$  Pa) carries air away from the surface of the food immediately before the container is sealed. This method is best suited to liquid foods where there is little air

trapped in the product and the surface is flat and does not interrupt the flow of steam (Juliano *et al.*, 2006). Aside exhaustion of cans, it is necessary to vent the retort to remove air which otherwise could form an insulating boundary film around the cans and hence preventing steam from condensing and causing under-processing (Juliano *et al.*, 2006).

### **2.11.2 Influence of pressure on meat quality**

Bacteria spores have been shown to resist high pressures even at 1000 MPa (Black *et al.*, 2007). Therefore, effective combinations of high pressures and heat are used for product sterilization. Ananta *et al.* (2001) pointed out that bacteria spores can be inactivated with selective pressure, temperature and time treatment. An initial chamber temperature between 60 °C and 90 °C and heating at 500 MPa through internal compressing can give an in-process temperature of 100 °C – 130 °C. This reduces processing time compared with conventional methods (Matser *et al.*, 2004).

Hugas *et al.* (2002) indicated that many factors are responsible for the rate at which microorganisms are inactivated during food processing under High Pressure Processing (HPP). Some of these factors include the type of organism present in the food, pressure level during processing, treatment time, treatment temperature, pH of the food and the water activity of the food. Generally, inactivation kinetics of microorganisms is directly proportional to increase in pressure.

### **2.11.3 Effect of temperature - time combinations on microorganisms**

Heat penetration data and kinetic data of microbial inactivation are necessary calculations following any thermal processing time at specific temperatures if sterility for any thermal products is to be achieved. To thermally inactivate any microorganism in food systems, the time-temperature history of the food during the thermal processing must be known and

be coupled with microbial death rate data to help calculate the effect of the thermal action on the destruction of the organism in the food (Holdsworth, 1985). All the same, certain quality losses occur in the food during thermal processing. Some of these include nutrient and colour losses. The target is therefore a time-temperature combination that best preserves food quality while the microorganisms are also destroyed. This is achieved through an optimization scheme after the kinetics of the quality degradation is calculated for such specific thermal time-temperature history for the microorganism. Necessarily, the microbial validation of the established thermal process is important step for process confirmation (Stoforos, 1995).

Un-refrigerated processed food products need high heat treatment to inactivate spoilage and pathogenic microorganisms. This however will result in undesirable change in chemical reactions leading to nutrients loss and other sensory attributes like colour, flavour and texture when heating time is extended (Awuah *et al.*, 2007).

The most potent and significant pathogenic spore-forming microorganism in thermally processed foods is *Clostridium botulinum*. Literature has extensive data on this microorganism. In most low acids thermally processed foods, a z value of 10 °C and a D<sub>121.1 °C</sub> value of 0.3 is enough to destroy the spores and produce safe food between temperature ranges of 110 °C – 130 °C (Holdsworth, 1985).

## **2.12 Process verification and validation**

In any thermally processed food, the objective is to obtain food that will not pose any public health risk after consumption. It is therefore necessary to attain the maximum level of lethality of the target organism in the processed food. To verify the lethality of the target organism, the food system is put through different time-temperature combinations,

system and techniques. The disadvantage is that some organoleptic properties and nutrients are lost through the thermal process (Holdsworth, 1985).

The kinetic data obtained from the heat penetration studies are used to design the thermal process schedule, the process design, validation and quality optimization of the food system as well as account for the nutrient loss in the processed food (Awuah *et al.*, 2007; Holdsworth, 1985).

### **2.13 The logarithmic order of bacteria destruction during sterilization**

The logarithmic order of bacteria destruction by heat stipulates that the same number of bacteria will die in successive units of time (Pflug and Esselen, 1953). Through mathematical methods, Ball (1928) introduced the terms 'F' and 'z' values in relation to thermal resistance of microorganisms. F value is designated the time needed to destroy an organism at 250 °F while z value is the slope of the thermal death time graph. For public health safety of low acids canned products a 10<sup>12</sup> decimal reduction of the initial microbial load (*Clostridium botulinum*) is adequate (Stoforos, 1995).

Process values are calculated by relating time and temperature data given by thermal death time curve of the target organism and the heating cooling curve of the container of food (Toepfer *et al.*, 1946). Well calculated thermal kinetic data is normally required to inactivate bacterial growth of processed food. The thermal treatment is then fused into the process design. Two broad mathematical models have been used to evaluate a process design namely the Arrhenius and Bigelow models. The Bigelow model has been used extensively for thermal processing of low acid foods (Ramaswamy *et al.*, 1989). Higher temperature with reduced time is required for thermal optimization (Swartzel, 1986). The Bigelow model is based on the principle of Thermal Death Time (TDT) from which the

Thermal Death Time Model (TDTM) is derived. Some process variables are calculated from the heat penetration data using the following formulae:

$$L = 10^{(T(t) - T_{\text{Ref}})/z}$$

Where

L = Lethal rate (min at T ref)

T = Processing Temperature (°C)

T ref = reference Temperature (121 °C)

t = time of processing in minutes

Z = Change in temperature needed to change the TDT by a factor of 10. Z value is 10 °C for botulinum widely used in food processing (Pflug, 1987).

The Bigelow model helps to develop the processing time and F value through numerical integration;

$$F_0 = \int_0^t 10^{(T - T_{\text{ref}})/z} dt$$

Where

F<sub>0</sub> = the integrated lethality at the slowest heating point in minutes

t = time of processing in minutes

T = temperature in degrees celcius at time t

T ref = reference temperature at 121 °C (250 °F)

Z = slope of the logarithm of the decimal reduction time, D, versus temperature for the specific organism. For *Clostridium botulinum*, z = 10 °C

## 2.14 Quality indices of canned meat products

Increasing demands for convenience foods by consumers are unlimited with much attention on food safety, quality and health (Kuypers and Kurth, 1995). Quality indices of

canned meat include colour, texture, aroma, taste, other sensorial attributes as well as chemical residues such as peroxides.

### **2.14.1 Lipid peroxidation**

Rice-Evans and Burdon (1993) defined lipid peroxidation (LP) as the oxidative deterioration of lipid products that contain carbon-carbon double bonds. The products formed from lipid peroxidation can be measured using several methods. Some of the products that are measurable include conjugated dienes, lipid hydroperoxides, aldehydes e.g. 4-hydroxynonenal and malondialdehyde (MDA) that react with thiobarbituric acid (TBA) to form thiobarbituric reactive substances (TBARS), isoprostanes, isofurans, exhaled gases such as pentane, lipid-protein adducts, lipid-DNA adducts etc (Fessel *et al.*, 2002).

MDA is a natural compound formed from the peroxidation of lipid products. This product is determined as evidence of lipid peroxidation which has harmful effects on living tissues. PUFA which are highly unstable usually breakdown to form several compound complexes which are mostly reactive carbonyl compounds. TBA assay is therefore used to measure the extend of MDA accumulation in tissues. High lipid tissues yield high TBARS. The aldehydic products formed from lipid peroxidation can react with TBA to yield TBARS which can easily be detected by spectrophometry. TBA reacts with other complexes and is therefore not specific. Modern methods such as the High Performance Liquid Chromatography (HPLC), spectrofluorimetry, mass spectrometry and chemiluminescence will yield better results (Devasagayam *et al.*, 2003).

Lipid peroxidation products reduce membrane fluidity and therefore change membrane functions. For instance, electrical resistance of tissues is reduced and membranes proteins

mobility restricted. Usually, peroxidative products in tissues membranes restrict membrane ability to act as a barrier. They weaken lysosomes and leak cytosolic enzymes from whole cells (Rice-Evans and Burdon, 1993). Lipid peroxidation has been associated with pathogenesis of a number of diseases and clinical conditions. Some of the pathologies and clinical diseases include premature birth disorders, diabetes, adult respiratory distress syndrome, aspects of shock, Parkinson disease, Alzheimer disease, various chronic inflammatory conditions, ischemia-reperfusion mediated injury to organs including heart, brain, and intestine, atherosclerosis, organ injury associated with shock and inflammation, fibrosis and cancer, preeclampsia and eclampsia, inflammatory liver injury, type 1 diabetes, anthracycline-induced cardiotoxicity, silicosis and pneumoconiosis (Yoshikawa *et al.*, 2000).

The main products formed from lipid peroxidation are LOOH which are fairly stable under physiological temperatures. But LOOH are decomposed when they react with transitional metals. Reduced iron complex compound react with LOOH similar to peroxides causing fission of the O-O bond to form alkoxyl radical which promote the chain reaction of lipid peroxidation. Fission of cyclic endoperoxides can result in the formation of MDA which easily react with TBA to form an adduct. Using spectrophometry method, a distinctive pink colour indicate its presence and amount (Rice-Evans and Burdon, 1993).

#### **2.14.1.1 TBARS assay**

TBARS assay can be performed by standard methods using MDA equivalents derived from tetraethoxypropane. MDA and other aldehydes have been identified as products of LP that react with TBA to give a pink coloured species that absorbs at 532 nm. The method involved heating of biological samples with TBA reagent for

20 min in a boiling water bath. TBA reagent contains 20% TCA, 0.5% TBA and 2.5 N HCl. After cooling, the solution is centrifuged at 2,000 rpm for 10 min and the precipitate obtained is removed. The absorbance of the supernatant is determined at 532 nm against a blank that contained all the reagents minus the biological sample. The MDA equivalents of the sample are calculated using an extinction coefficient of  $1.56 \times 10^5 \text{ M}^{-1} \text{ cm}^{-1}$ . To reduce interference from iron released during homogenization, it is advisable to include antioxidant/ iron-chelator like butylated hydroxytoluene (BHT) or EDTA (Nelson *et al.*, 1994; Devasagayam *et al.*, 1993).

#### **2.14.2 Meat texture**

Quality is a fundamental reason for food evaluation and texture is one of the sensory attribute of great important quality that is evaluated. Some methods used to evaluate texture include chemical, mechanical and sensory methods (Nadulsi, 2000). The most important of all textural attributes is hardness (tenderness) (Martinez *et al.*, 2012).

Nadulsi, (2000) used TPA Test on three kinds of pork butcher's meat and found out that TPA Test significantly affect sample size and deformation degree of samples for hardness, cohesiveness and elasticity but has no influence on the loading speed of the samples (Nadulsi, 2000). In a study to evaluate the relationship between sensory evaluation and instrumental measurements of texture of rabbit meat (Martinez *et al.*, 2012) generally found out that both instrumental and sensory evaluations are necessary to evaluate tenderness of rabbit meat due low correlation between them.

The International Organization for Standardization has defined texture as “all the mechanical, geometrical and surface attributes of a product perceptible by means of mechanical, tactile and, where appropriate, visual and auditory receptors”. Texture profile

analysis (TPA) is an important objective means of determining the palatability of a meat products since it compares favorably sensorially (Lyon *et al.*, 1980). The texture of meat is a sensory property and it shows meat tenderness, product yields, mouth feels and edibility of meat products. TPA is a significant determinant of texture changes in meat (Chang *et al.*, 2012)

## **CHAPTER THREE**

### **3.0 MATERIALS AND METHODS**

#### **3.1 Survey of consumer demand for grasscutter meat**

##### **3.1.1 Study design and location**

The study was a cross-sectional survey of grasscutter consumers in three of the six zonal councils (Kotoku, Amasaman and Pokuase) of the Ga-West Municipality in the Greater Accra Region of Ghana. The Ga West Municipality has a population of 262,742 representing 6.6% of the Greater Accra Regional population (Ghana Statistical Service, 2013) with a land area of 305.4 sq km made up of 193 communities. There are six zonal councils within the municipality namely Ofankor, Pokuase, Mayera, Amasaman, Ayikai Doblo and Kotoku.

##### **3.1.2 Sample size and sampling techniques**

The sample size was 200 consumers of grasscutter meat (100 male and 100 female), within Pokuase, Amasaman and Kotoku zonal councils which were randomly selected by simple balloting. The convenience sampling technique was used to select the 200 consumers.

#### **3.2 Data collection**

##### **3.2.1 Instrument for data collection and pre-testing of questionnaire**

A structured questionnaire was administered to respondents to elicit their response on the cost, accessibility, frequency of consumption, preferred meals and cooking methods for grasscutter meat. The questionnaire was pretested at Lapaz in the Ga-South Municipality prior to being administered.

### **3.2.2 Procedure for data collection**

Visits were made to chop bars, restaurants and other food establishments in Amasaman, Kotoku and Pokuase to administer the questionnaire to consumers who admitted to eating grasscutter meat within the past three months. The purpose of the study was explained to the consumers and those who were interested in participating in the study were given questionnaires to fill. A total of 13 chop bars and restaurants were visited (7 in Amasaman, 4 in Pokuase and 4 in Kotoku).

### **3.3 Materials**

Twenty two, one year old male grasscutter were obtained from a local farmer in Tema in the Greater Accra region of Ghana for thermal processing.

### **3.4 Preparation of grasscutter meat**

The grasscutter were slaughtered early in the morning on the day of processing, singed and eviscerated. Carcasses were transported on ice in an ice chest to the Cameron Meat Laboratory of the Animal Science Department, University of Ghana within two hours after slaughter. Measurements of body parts (weight and length) were determined using the Waymaster scale (Precision Weighters, Reading, England) and a tape measure. The carcasses were then cut up into smaller portions using a Balme Saw Meat Cutter (Food Processing JWB-250, Fujee Tech). Each portion was weighed, skinned and deboned. The boneless meat was minced using an electric mincer (M. Gilbert Ltd. 1109/1115 Greenford Middx). Colour was determined for the minced meat prior to thermal processing.

### **3.5 Salt addition**

Granulated salt (79.80 g) was weighed and hand mixed with 7.90 Kg of minced grasscutter meat prior to processing. Hence, about 1% of salt was added to the minced grasscutter meat.

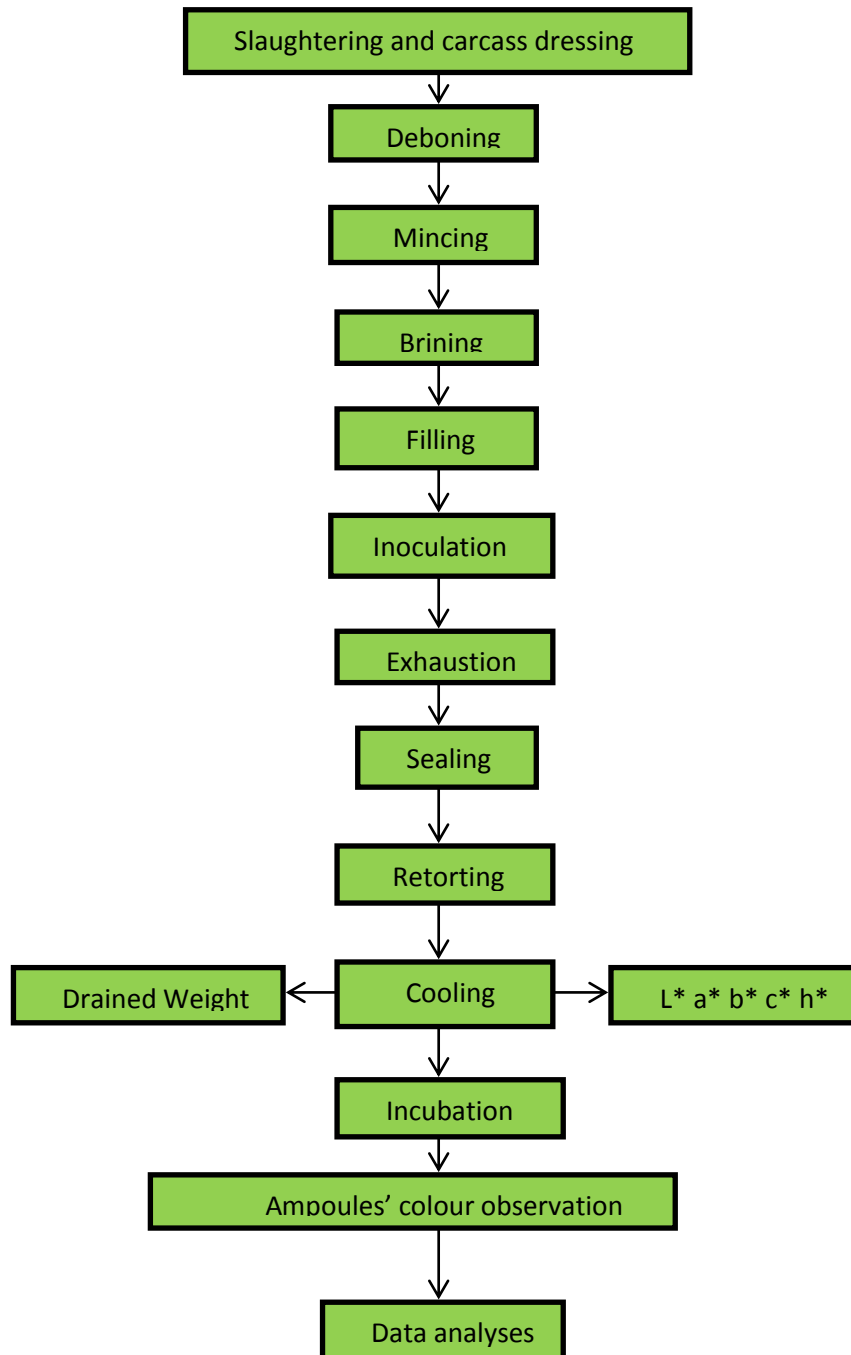
### **3.6 Determination of thermal process parameters**

A 3×3 factorial design (giving a total of 9 experimental units) was used for the thermal process (Table 1). The processing temperatures (109 °C, 116 °C and 121.1 °C) and processing times (30, 45 and 60 minutes). The processing was done in triplicate. Food contact cans of size (307 mm × 200 mm) from Crown Cans Ghana Ltd. Tema, were used for canning the meat. Each can contained  $140.0 \pm 2$  g of raw minced meat. The cans containing meat were exhausted in a Comfort Steamer Pot (Chaoan Lifa Stainless Steel Industrial Co., Ltd.; Lihua Road, Caitang, Chaoan, Guangdong) at the same time for fifteen minutes. Cans after exhaustion were immediately hermetically sealed manually using Ives-Way Manual Can Sealer (Model 500, Round Lake Beach, Illinois, U.S.A.). Seamed cans were loaded into a pressure canner (All American Pressure Cooker/Canner, Model 941, Wisconsin Aluminum Foundry Co., Inc, Manitowoc, North Carolina, U.S.A) and sterilized at their respective time-temperature combinations. Wireless temperature data loggers (Ellab Pro Tracksense mini and double rigid sensor, Hillerod, Denmark) measuring temperature up to 150 °C and above were fixed at the centers (cold point) of three cans to record the cold point temperatures from which sterilization values would be calculated. Both product core (ie cold point) and heat distribution temperatures were recorded by the temperature data logger. After thermal processing, the cans were removed from the retort and cooled immediately in open air. Figure 1 shows the flow chart for the process.

**Table 1: Experimental run order for thermal process schedule**

Run order	Temperature (°C)	Time (mins.)
1	121	45
2	121	60
3	116	60
4	109	60
5	116	45
6	109	45
7	109	30
8	116	30
9	121	30

The run order of thermal indicators was randomized by simple balloting



**Figure 1: Flow chart of the grasscutter meat canning process**

### 3.7 Confirmatory test on the adequacy of the thermal process schedules using *Geobacillus stearothermophilus* spores

To ascertain the adequacy of each of the 27 thermal process schedule (ie temperature time combinations), cans after inoculation were exhausted and immediately hermetically seamed manually using Ives-Way Manual Can Sealer (Model 500, Round Lake Beach, Illinois, U.S.A.). Seamed cans were loaded into pressure canner (All American Pressure Cooker/Canner, Model 941, Wisconsin Aluminum Foundry Co., Inc, Manitowoc, North Carolina, U.S.A) and sterilized at their respective time-temperature combinations. Wireless temperature data loggers (Ellab Pro Tracksense mini and double rigid sensor, Hillerod, Denmark) measuring temperature up to 150 °C and above were fixed at the centers (cold point) of three cans to record the cold point temperatures.

Upon cooling the cans were opened and the ampoules removed and incubated at 60°C for 48 hours. Color development of the ampoules that were removed from the 27 time-temperature combinations were compared with ampoules that were sterilized at 121.1 °C for 15, 20, 25, 30, 45 and 60 minutes .

**Table 2: Experimental run order for thermal process schedule**

Run order	Temperature (°C)	Time (mins.)
1	121	15
2	121	30
3	121	45
4	112	20
5	121	25
6	121	45

### 3.8 Storage conditions for shelf life assessment

Canned minced grasscutter labeled for storage studies were incubated at 27 °C and response variables of colour, drained weight and TBARS were monitored for 6 weeks.

### 3.9 Drained weight of canned minced grasscutter meat

The drained weight of canned grasscutter samples was determined according to the procedure described by Wattanachant *et al.* (2008). The weight of meat samples was measured after draining off the media for 2 minutes and regarded as the drained weight of canned product.

### 3.10 Colour of canned minced grasscutter

A portable Minolta HunterLab Colorimeter (Model CR-310, Osaka, Japan) connected to Minolta data processor (DP-301 for Chroma Meter, CR 300 series, Osaka, Japan) was used to determine CIEL\* (Lightness), a\* (+/-, red to green), and b\* (+/-, yellow to blue) values of the meat samples. A white ceramic tile with a specification of Y= 94.8, x= 0.3128, y = 0.3192 was used to standardize the colorimeter. CIE L\*, a\*, b\* colour values were measured in triplicates and were used to calculate the differences in total colour.

The colour (L\*a\*b\*) of the canned minced grasscutter meat was determined before and after retorting for each thermal process schedule. Total colour difference ( $\Delta E^*$ ) was calculated using the equation described by (Minolta, 1991). L\*<sup>t</sup> a\*<sup>t</sup> b\*<sup>t</sup> represented unretorted minced grasscutter meat as the target colour.

$$\Delta E^* = \sqrt{((L^* - L^{*t}) + (a^* - a^{*t})^2 + (b^* - b^{*t})^2)}$$

Where  $\Delta E^*$ - total color difference, L\*<sup>t</sup> a\*<sup>t</sup> b\*<sup>t</sup> – target colour of unretorted minced grasscutter meat and L\* a\* b\*- colour of retorted minced canned grasscutter meat. Other

attributes of colour are the Chroma (colour purity) denoted by C and Hue angle, denoted by H;

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \text{ and } H^* = \tan^{-1}(b^*/a^*)$$

$$\Delta L^* = L^*_{\text{sample}} - L^*_{\text{standard}}$$

Hunterlab (1996) described the total colour difference as follows:

+  $\Delta L^*$  means sample is lighter than standard

-  $\Delta L^*$  means sample is darker than standard

$$\Delta a^* = a^*_{\text{sample}} - a^*_{\text{standard}}$$

+  $\Delta a^*$  means sample is redder than standard

-  $\Delta a^*$  means sample is greener than standard

$$\Delta b^* = b^*_{\text{sample}} - b^*_{\text{standard}}$$

+  $\Delta b^*$  means sample is yellower than standard

-  $\Delta b^*$  means sample is bluer than standard

### 3.11 Evaluations of TBARS

Quantitative analysis of thiobarbituric acid reactive substances (TBARS) was used to determine the extent of oxidation in the stored canned meat as described by (Witte *et al.*, 1970) with modifications. Ten (10) grams of meat sample was blended with 20 ml of ortho-phosphoric acid containing 20% trichloroacetic acid. The sample was quantitatively transferred into a 100 ml Erlenmeyer flask with 30 ml distilled water. The volume was made up to 100 ml and filtered (Whatman No. 1 filter paper). A 5 ml aliquot of the filtrate was reacted with 5 ml of 0.005 M thiobarbituric acid (TBA) solution in the dark at room temperature for 15 hr. Absorbance were determined at 530 nm with a spectrophotometer (CECIL INSTRUMENT: CE 3041, 300 series, Cambridge, England). Absorbance (530 nm) values from reactions of 5 ml TBA (0.005 M) solution with serial dilutions ( $10^{-4}$  –  $10^{-$

<sup>5</sup> M) of 1, 1, 3, 3-tetraethoxypropane (TEP) (MERCK Chemicals, Darmstad, Germany) was used to generate a standard curve. Quantities of TBARS in samples were calculated from this standard curve.

### **3.12 Sensory analysis**

Even though all products that were canned at 121.1°C for 15, 20, 25, 30, 45 and 60 minutes were sterile based on the ampoules color development confirmatory tests, only canned minced grasscutter processed at 121.1 °C for sixty minutes was used for the sensory study. The sensory procedure followed an acceptability test (Stone and Sidel, 2004). Fifty untrained panelists who were regular consumers of grasscutter meat were used for the study. Participants were mostly undergraduates and graduates students of the Department of Family and Consumer Sciences of the University of Ghana who were willing to take part in the sensory analysis. The seating arrangement of the participants was such that they would not influence one another's judgment. Sixty (60) gram samples were placed in transparent plastic cups and coded. Each panelist was presented with the coded sample and asked to score the various sensory attributes using a 7-point Hedonic scale provided on the accompanying sensory ballot.

### **3.13 Statistical Analyses**

Survey data was coded and analyzed using Statistical Package for Social Sciences (SPSS) version 16.0 for windows. The survey data were analyzed for percentages, frequencies and chi square test of associations. Laboratory data were analyzed using Microsoft Excel 2010 to generate graphs. Level of significance was set at  $p \leq 0.05$ .

## CHAPTER FOUR

### 4.0 RESULTS AND DISCUSSION

#### 4.1 Survey of consumers

##### 4.1.1 Demographic characteristics of respondents

Table 3 displays the demographic characteristics of the consumers of grasscutter meat that were interviewed. Consumption of grasscutter meat spanned through all the classified age groups, even though it appeared more popular with the younger consumers than the older ones. This may be because the younger consumers are more likely to eat out and are therefore more likely to be found in eateries where this study was conducted. It is possible that if consumers were randomly sampled from homes, instead of from eateries, a different observation may have been made. Odebode *et al.* (2012) reported that there is no age limit to the consumption of grasscutter meat. Adefalu *et al.* (2014) reported that consumers in the active age group are more likely to obtain earnings and therefore have higher purchasing power to purchase grasscutter meat compared with those above 60 years who do not obtain earnings. Since the compulsory retiring age is 60 in Ghana, it is possible that the younger consumers who are still very active can better afford to eat out than the older ones who are probably more health conscious.

Table 3 also shows that the respondents came from all over the country, and were also of different religious backgrounds. Majority of the respondents were Christians representing 79.0%. The next populous religion was Islam with 17.5% while 3.5% of respondents practice African Traditional Religion. These distributions also reflect that of the national distribution of Ghanaians according to their religious beliefs based on Ghana's 2010 Population Census where Christians represent 71.2% of Ghana population, 17.6% Muslims, 5.2% Traditional believers and other believers constituting 6% of the population.

**Table 3: Demographic characteristics of respondents**

<b>Variable</b>	<b>Responses</b>	<b>Percent (%)</b>
<b>Age Group</b>	< 30	41.0
	31-40	28.0
	41-50	19.0
	51-60	11.0
	> 60	1.0
<b>Region</b>	Eastern Region	17.5
	Greater Accra	15.5
	Volta Region	13.0
	Upper West	12.5
	Central Region	9.0
	Ashanti Region	9.0
	Brong-Ahafo	7.0
	Northern Region	7.0
	Western Region	5.5
Upper East Region	4.0	
<b>Religion</b>	Christian	79.0
	Muslim	17.5
	Traditional	3.5
<b>Marital Status</b>	Married	45.5
	Single	42.0
	Divorced	4.5
	Separated	4.0
	Widowed	4.0
<b>Dependents</b>	< 6	69.0
	6-10	30.5
	> 10	0.5
<b>Educational Qualification</b>	Tertiary	63.0
	Senior High	28.5
	Basic Education	7.0
	Non-Formal Education	1.5

Consumption of grasscutter is so popular among the respondents that it is eaten at various social settings including family food since majority of respondents (45.5%) were married and with many dependents. Many young couples and single adults are more likely to eat outside home as a result of work schedules. Majority of respondents (69.0%) had less than six dependents that they cared for while 41% of respondents took care of more than five

dependents. This shows that consumers are able to buy grasscutter meat when they cater for less people because they tend to have higher purchasing power as compared to those with many dependents.

The consumption of grasscutter meat seemed to be associated with educational level. Majority of the respondents (63%) had tertiary education followed by Senior High Education (28.5%). Only 7% of respondents finished Basic Education while 1.5% never had any formal education. The majority who had tertiary education are more likely to have better purchasing power since most of them might be working and receiving salaries. Adefalu *et al.* (2014) observed that greater number of consumers who got to high educational levels consume grasscutter meat most. This may be attributed to their awareness of the high nutritional value of grasscutter meat compared with other conventional meat and meat products.

#### **4.1.2 Association between demographic variables and grasscutter meat consumption habits**

Table 4 shows the associations between selected demographic variables and some indicators of grasscutter meat consumption habits. Grasscutter meat is processed using different methods, some of which include smoking, roasting, frying, grilling and boiling. While there was no significant association between gender and the preferred method of preparing and cooking grasscutter meat, the consumers' age, marital status and number of dependents were significantly ( $p \leq 0.05$ ) associated with preferred methods of cooking grasscutter meat. Majority of the younger age group preferred smoked grasscutter meat (Appendix 1). Respondents who were single or married with two children as well as those with two dependents also preferred smoked grasscutter meat. The high preference for smoked grasscutter is similar to the findings of Omole *et al.* (2005); Ahenkan and Boon,

(2010) that many consumers prefer the flamed grasscutter meat than the scalded grasscutter meat. One of the key reasons was that the flamed meat has better flavour than the scalded grasscutter meat.

**Table 4:  $\chi^2$  test for selected dependent variables on demographic characteristics**

<b>Cross tabulation Dependent variable</b>	<b>Demographic variable</b>	<b><math>\chi^2</math></b>	<b>Likelihood Ratio</b>	<b>P-value</b>
<b>Preferred method of preparing and cooking grasscutter meat</b>	Gender	2.230	2.240	0.8
	Age	50.231	43.401	0.01
	Marital status	31.543	36.144	0.05
	Dependents	62.457	70.397	0.04
	Religion	15.461	14.953	0.1
	Region	48.189	54.006	0.3
	Educational level	23.110	20.459	0.08
<b>Frequency of consumption of grasscutter meat</b>	Gender	0.292	0.292	0.9
	Age	14.910	16.366	0.2
	Marital status	20.863	23.267	0.008
	Dependents	37.500	36.869	0.005
	Religion	3.303	3.701	0.5
	Region	22.576	25.623	0.2
	Educational level	4.301	4.620	0.6
<b>Limitation to consumption of grasscutter meat</b>	Gender	5.949	7.165	0.4
	Age	28.146	29.587	0.8
	Marital status	51.274	25.197	0.001
	Dependents	67.260	56.223	0.1
	Religion	11.530	12.381	0.5
	Region	45.682	43.338	0.8
	Educational level	12.237	16.260	0.8
<b>Preference for grasscutter meat over other meat</b>	Gender	0.000	0.000	1
	Age	9.257	10.521	0.2
	Marital status	3.984	4.297	0.4
	Dependents	18.072	20.750	0.03
	Religion	0.200	0.195	0.9
	Region	4.212	4.352	0.9
	Educational level	0.705	0.699	0.9

*P ≤ 0.05 are statistically significant*

Among all the demographic variables, only marital status and the number of dependents were significantly associated with the frequency of consumption of grasscutter meat. There were no differences in the frequency of consumption between male and female

consumers. Similarly there were no trends in the frequency of consumption among religious or age groups and educational level. Adefalu *et al.* (2012) reported that restaurant settings were frequently the locations for the consumption of bushmeat. Daily frequency of consumption of bushmeat was highest followed by weekly consumption while occasional consumption was the least frequent. The cost and availability of grasscutter were limiting factors to the consumption of grasscutter meat and they were significantly associated with the marital status of respondents (Chi-square = 51.274; P-value = 0.001). Respondents who had two dependents preferred grasscutter meat over other conventional meat and animal products such as chevon, mutton, beef, chicken and eggs. Though fear of the deadly Ebola virus lurked around in some West African countries, it did not have much influence on respondents' consumption of grasscutter meat. More than 80% of Ghanaians in both rural and urban areas prefer bushmeat and would eat it if available (Blankson-Arthur *et al.*, 2011). Consumers are therefore more likely to continue eating grasscutter meat when made available at affordable prices. Among the limitations to the consumption of grasscutter meat, the complaints on chemical contamination were basically on the use of poisonous substances to hunt these animals. The addition of preservatives during preservation and the possible consumption of contaminants by the animals during feeding especially those in the wild were all not significant factors affecting consumption of grasscutter meat.

#### **4.1.3 Factors considered in purchasing grasscutter meat**

Respondents consider price as very important when purchasing grasscutter meat for consumption (Table 5). When the price is too high they prefer a substitute. Only few consumers said price was either unimportant (4%) or totally unimportant (1.5%) when they are purchasing grasscutter meat and will purchase the meat at any quoted price. Sixty

six percent (66%) of respondents were also particular about the parts of grasscutter they consumed considering choice cuts as either important or very important in making their purchasing decisions. Many respondents considered taste as a very important consideration in making purchasing decisions. Majority (78%) of respondents had knowledge on the nutritional composition of grasscutter meat and considered nutritional composition as an important or very important parameter when buying grasscutter meat. Knowledge on grasscutter nutritional content included low cholesterol and high protein levels. However, 5% of respondents had no knowledge on grasscutter nutrients composition.

**Table 5: Factors considered in purchasing grasscutter meat**

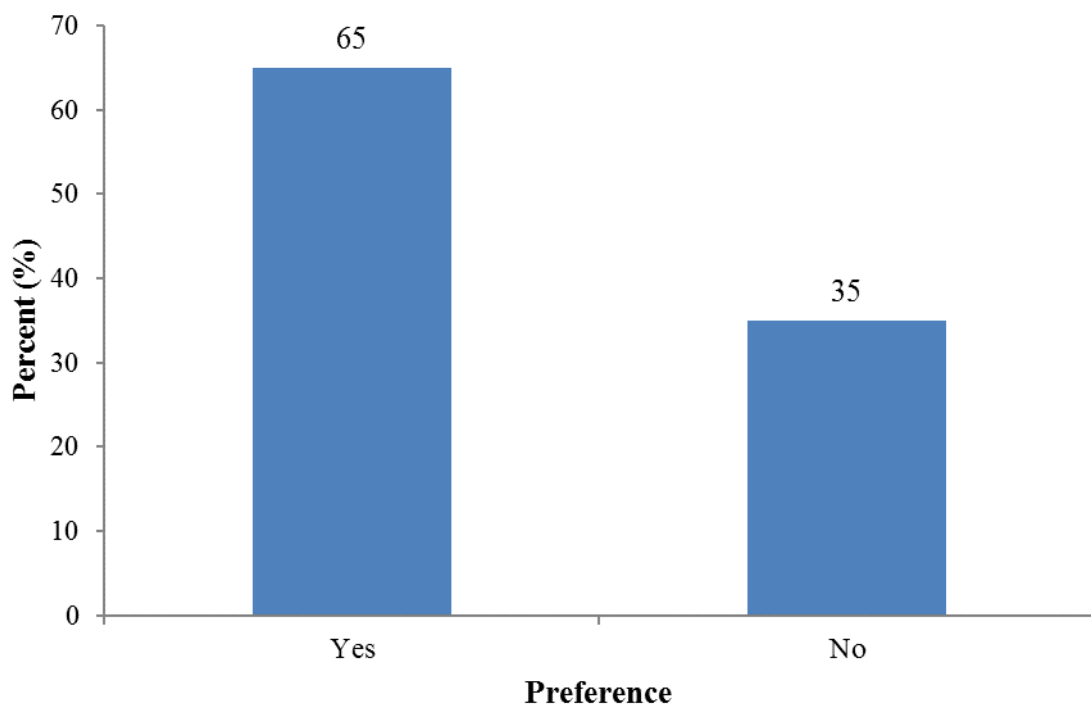
Factor	Ranks				
	Totally Unimportant	Unimportant	Neutral	Important	Very Important
Price	3(1.5%)	8(4%)	18(9%)	28(14%)	143(72%)
Choice Cut	3(1.5%)	11(6%)	55(28%)	72(36%)	59(30%)
Taste	4(2%)	2(1%)	16(8%)	75(38%)	103(52%)
Nutritional Knowledge	5(2.5%)	5(2.5%)	35(18%)	87(44%)	68(34%)
Processed(Smoked)	3(1.5%)	19(10%)	50(25%)	51(26%)	77(39%)
Freshness	3(1.5%)	26(13%)	69(34.5%)	32(16%)	70(35%)

#### 4.1.4 Preference for grasscutter meat over other meats

Many respondents (65%) would buy smoked grasscutter attributing it as either important or very important. Fifty one percent of respondents agreed that it is important or very important for them to consider the freshness of grasscutter meat. This finding is similar to

Odebode *et al.* (2011) who reported that consumer needs for both fresh and smoked grasscutter is unmet.

Majority of respondents (65%) preferred to eat grasscutter meat compared with other meats (Figure 2). Preference for grasscutter meat will continue to increase since the meat is likely to be readily available in the near future through breeding programmes and farming activities being instituted by the government of Ghana and NGOs. Despite these breeding programmes, grasscutter meat may still not be adequate and available enough to meet demands for the meat.



**Figure 2: Preference for grasscutter meat over other meats**

Individuals should be encouraged to rear the animals at home to complement their protein diets and cut down the market price for the meat. Thirty five percent of respondents did not prefer grasscutter meat over other meats (Figure 2). Reasons included the cost of the meat being too high, unavailability of the meat on regular basis, the prevalence of Ebola

virus and lack of knowledge on the nutritional composition of the meat. Other reasons were the preference for a variety of meats in their diets and dislike for the meat.

#### 4.1.5 Order of preference for protein sources

Some of the animal protein sources respondents would eat in the absence of grasscutter meat included goat meat which was ranked second and third respectively among the list of animal protein sources (Table 6). Respondents preferred chicken in the absence of goat meat while beef, fish and eggs followed preference respectively. The results agreed with works of Lynwood (1990); Assogbadjo *et al.* (2005) who found rodents as the most commonly consumed meat among with grasscutter being the most preferred source of protein.

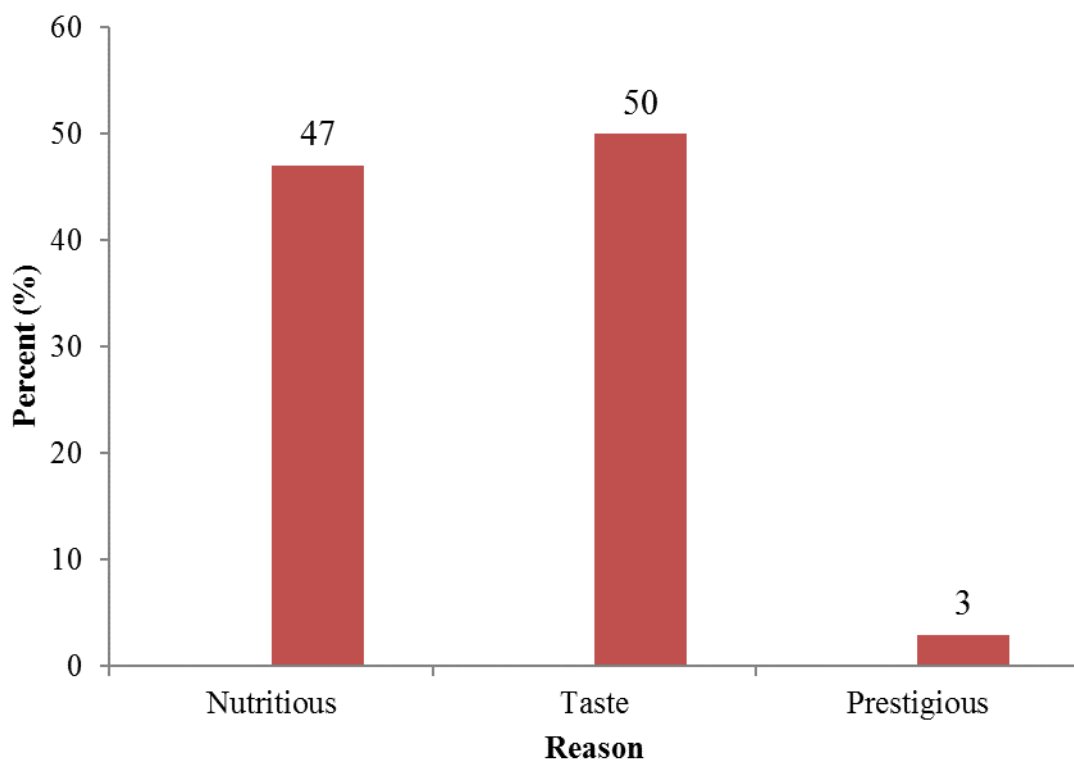
**Table 6: Order of preference for protein sources**

Protein sources	Order of preference (%)					
	1	2	3	4	5	6
Grasscutter meat	58.0	12.0	12.0	4.5	9.0	4.5
Goat meat	12.0	41.0	25.0	15.0	5.0	2.0
Beef	6.5	6.0	19.5	33.0	27.0	8.0
Fish	14.0	20.0	19.0	19.5	19.5	8.0
Chicken	7.5	20.0	20.0	20.5	27.5	4.5
Eggs	0.5	1.5	5.0	6.0	12.0	75.0

Cimino (2009) and Hoffman *et al.* (1999) also reported the decline in fish consumption over the past years due to over exploitations which hitherto had been the major animal protein food in West Africa for centuries. Hence, since fish is no more available in large

quantities to provide adequate protein and domestic animals are also consumed occasionally, much attention has shifted to the consumption of grasscutter.

Figure 3 illustrates the reasons for preference for grasscutter meat over other meat and meat products. Out of the one hundred and thirty respondents who preferred eating grasscutter meat over other meat, 65 responses representing 50% ate it because of its superior taste, about 47% ate the meat because of its high nutritional composition such as high protein food and less fat compared to other meats.



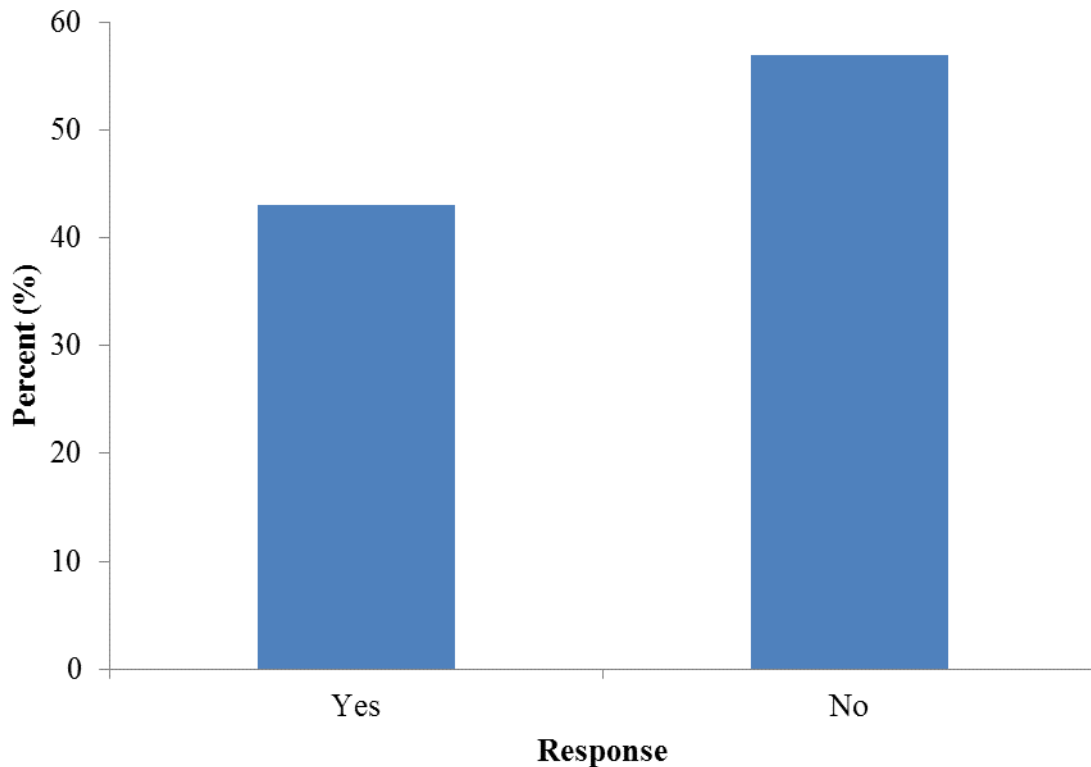
**Figure 3: Reasons for preference for grasscutter meat**

In the work of Adeyeye and Jegede (2010), they found out that grasscutter meat contains high levels of both essential and non-essential amino acids and Adeyeye *et al.* (2012) further revealed good PUFA in grasscutter meat. Louw (2008) found the protein content to be 22% and 4% fat in *Thryonomys swinderianus*. Only about 3% ate the meat because of prestige of the meat and its social acceptance. Major reasons for the consumption of

bushmeat included, availability, affordability and nutritional value of the meat (Adefalu *et al.*, 2012).

#### **4.1.6 Acceptance for canned grasscutter meat**

More than half (57%) of respondents did not want value-addition to grasscutter meat through canning (Figure 4). Respondents who did not want value addition to grasscutter meat attributed reasons to loss of originality of the meat (taste, freshness, flavor, texture, nutrients loss) and further increase in the price of the product due to added cost of packaging, branding and other production cost. 43% of respondents however would like to purchase canned processed grasscutter meat. Reasons given included convenience such as ease of use, portability and its application on many dishes that can be served. Adefalu *et al.* (2012) reported that consumers nowadays require products that provide the convenience of portability and preparation.



**Figure 4: Response on acceptance for canned grasscutter meat**

#### **4.1.7 Most preferred processing and preservation method for grasscutter meat**

Consumers ranked the processing and preservation methods for grasscutter meat on a five point scale with 1 being the most preferred processing and preservation method and 5 the least processing and preservation method (Table 7). The results show that majority of the respondents preferred smoked grasscutter. Reasons ascribed to the preference for smoked meat include added flavour from smoke, the meat being microbially safe due to the antimicrobial activity of smoke, free from chemical additives and the high social acceptance of smoked meat and meat products in Ghana. This is similar to the findings of Omole *et al.* (2005); Ahenkan and Boon (2010) that many consumers prefer the flamed grasscutter meat than the scalded grasscutter meat with reason that the flamed meat has better flavor than the scalded grasscutter meat. However, the two traditional methods of processing grasscutter have no significant effect on the weight of the organ, dressing

percentage, chemical composition and general acceptability of grasscutter meat hence, consumers can use any of the two methods for removing the fur of grasscutter. Kabir (2005) also reported that the demands for both smoked and fresh grasscutter is unmet in West Africa.

The next most preferred form of processed grasscutter meat was dried grasscutter meat. Respondents attributed preference for dried grasscutter to its intense flavor from the fermentation process, microbial safety, chemical safety and its natural preparation. Vacuum packed grasscutter meat was rated third due to its freshness and lack of additives. Respondents accepted canned minced grasscutter meat as their fourth rank of preferred processed grasscutter meat against canned grasscutter meat in rank five. Reason for preferences for canned minced grasscutter meat included the familiarity of corned beef which is widely accepted.

**Table 7: Consumers ranking of processing and preservation methods for grasscutter meat**

<b>Ranking scale (%)</b>						
<b>Most preferred processing and Preservation method</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>Total</b>
Smoked grasscutter	70	16	6	5	3	100
Dried grasscutter	9	55	14	12	10	100
Vacuum packed grasscutter	5	5	45	20	25	100
Canned corned grasscutter	9	9	15	34	33	100
Canned chunks grasscutter	9	16	20	25	30	100

However, the low rankings for canned grasscutter products by respondents were because of the familiarity they had with smoked, dried and fresh grasscutter meat. Canned

grasscutter has undoubtedly higher price tags compared to smoked or fresh grasscutter. Respondents are more likely to accept the canned products if they are familiar with the products. Nevertheless it remains a daunting task to penetrate into the markets with the products if cost is not reduced.

#### **4.2 Physical measurements and thermal process schedules for canning minced grasscutter meat**

Whole length dressed grasscutter as well as body parts were measured with a tape measure. Each carcass was weighed wholly and cut into body parts and weighed taken with the scale. Cut portions were deboned without the skin and minced. Colour of minced grasscutter was determined prior to canning. Different time-temperature combinations were used to determine the adequacy of sterilization of the autoclave using inoculated pack test study.

##### **4.2.1 Physical characteristics of grasscutter**

Tables 8 and 9 show the physical characteristics of a one year old grasscutter (male). The total length of a one year old male grasscutter is about 55.0 cm. The head length and trunk alone constitutes about 66% of the total length of the grasscutter. Olayemi (2002) reported the total body of adults grasscutter' length measuring 35 cm to 60 cm and its tail length range from 7 cm to 25 cm. The average weight of a one year old dressed grasscutter is about 1.85 kg with about 50% boneless meat excluding the offals. The average dressed weight excluding the head, and offals was 71% of the live weight, which is higher than the average 65% of live weight reported by Barwa (2009).

**Table 8: Average measurements for one year old male grasscutter**

<b>Body Part</b>	<b>Length (cm)</b>
Carcass length (measured from nose to tip of tail)	55.0
Head circumference	22.6
Chest circumference (measured between 1 <sup>st</sup> and 2 <sup>nd</sup> rib)	32.3
Stomach circumference (measured just after the last rib)	34.4
Length across shoulder	30.9
Head length	8.9
Trunk	27.3
Length across thigh	35.9

**Table 9: Average body weight for one year old male grasscutter**

<b>Body part</b>	<b>Mean Weight (g)</b>
Dressed weight	1,850
Boneless	920
Bone	400
Head	260
Skin	140
Lungs, kidneys, liver	100
Tail piece	20

#### 4.2.2 Thermal process parameters for canned minced grasscutter meat

Table 10 shows the sterilization values for different time-temperature combinations. The results show that adequate sterilizations were achieved at 121 °C for the entire retort times (minutes) as well as 116 °C for 60 minutes. The values were above the sterilization value of 3.0 for *Clostridium botulinum* spores. The rest of the thermal indicators were below the

target sterilization value of 3.0 and hence were not adequately sterilized. The results indicate that complete sterilization of bacterial spores can be attained at 121 °C for 30, 45 and 60 minutes.

**Table 10: Sterilization times (Fo) of canned minced meat during retorting**

Run order	Retort Temperature (°C)	Time (mins.)	Sterilization time (Fo) min
1	121	45	47.1
2	121	60	47.7
3	116	60	39.7
4	109	60	1.2
5	116	45	2.7
6	109	45	2.1
7	109	30	1.9
8	116	30	2.0
9	121	30	24.8

#### **4.2.3 Adequacy of the thermal process schedules using *Geobacillus stearothermophilus* spores**

For maximum lethality and greater safety of quality processed food, it is necessary to verify and validate the process design of the thermal system. One way of verifying and validating a process design is employing the inoculated pack or count reduction methods. In this procedure a known microorganism with known resistance is put into the food and is subjected to different heating times at one or a number of different processing temperatures and the product incubated at growth temperature for survivors. A safe

product will yield no survivors at the end of the incubation period. A combination of the microbiological validation using surrogates and monitoring the chemical changes in the product during incubation are effective and excellent ways of lethality assurance in the food through the integrated time-temperature combination (Awuah *et al.*, 1993). Another way of assuring consumers of safe processed food is the combined graphical representation of the time-temperature combinations for the destruction of pathogenic spores (Holdsworth, 1985).

Table 11 shows the response of *Geobacillus stearothermophilus* in different time-heat treatments after 48 hr. incubation at 60 °C. Sterikon Plus Bioindicator (*Geobacillus stearothermophilus* ATCC 7953) suspended in ampoules that were used for the inoculated study possessed the following specificity:

$$n = 5 \times 10^5 - 1 \times 10^7 \text{ spores per unit}$$

$$D_{121} = 1.5 \text{ to } 2.0 \text{ minutes}$$

$$Z\text{-value} = 7\text{--}10 \text{ }^\circ\text{C}$$

There was evidence of growth when the ampoules were heat treated at temperatures 109°C and 116 °C for 30 minutes, 109 °C and 116 °C for 45 minutes and 109 °C for 60 minutes. Growth of the organism was inhibited at 116 °C for 60 minutes and at 121 °C for 30, 45 and 60 minutes.

**Table 11: Effect of process schedule on survival of test organism**

Time (minutes)	Temperature (°C)		
	109	116	121
30	Growth	Growth	×
45	Growth	Growth	×
60	Growth	×	×

All process schedules where the ampoule changes colour from red (original colour) to yellow showed growth and hence inadequate sterilization. Ampoules that remained red in colour after incubation indicated sufficient sterilization. The control ampoule was unsterilized and incubated and it also changed from red to yellow indicating growth of the spores. The results show that adequate sterilization of canned minced grasscutter meat can be achieved at the non-growth set points.

#### **4.2.4 Total colour change of canned minced grasscutter**

Total colour difference ( $\Delta E^*$ ) indicates the magnitude of colour change in the retorted products when compared to the unretorted product.  $\Delta E^*$  were calculated from the measured  $L^*a^*b^*$  values of the retorted and the unretorted minced canned grasscutter product. From Table 12, it was observed that the colour variations increased with increasing processing temperature at constant time per process schedules. However, the effect of colour change tends to decrease with the severity of the thermal processes.

**Table 12: Total colour differences ( $\Delta E^*$ ) of canned minced grasscutter**

Temperature ( $^{\circ}\text{C}$ )	Time (mins)	$\Delta E^*$
109	30	16.00
116	30	16.19
121	30	16.96
109	45	15.71
116	45	16.26
121	45	17.05
109	60	2.72
116	60	2.49
121	60	6.19

$\Delta E^*$  - Total colour difference,

Control – Grasscutter meat that was not retorted/sterilized

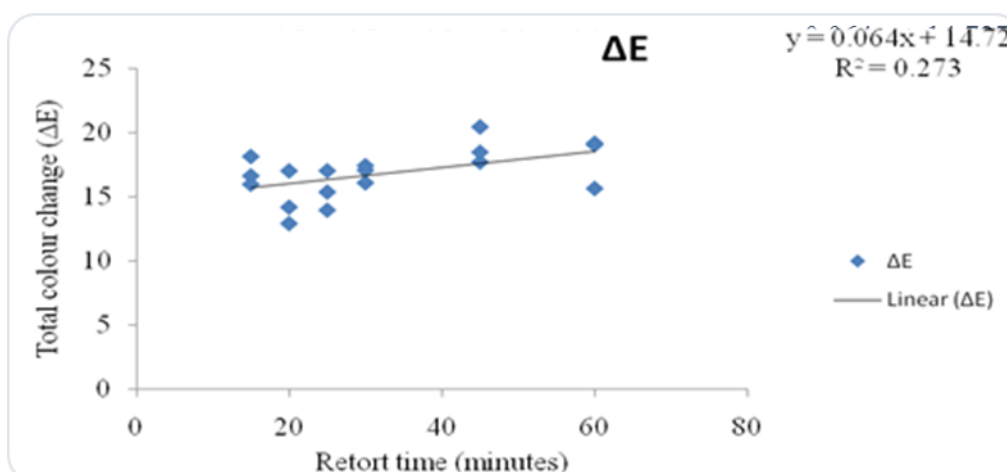
#### 4.2.5 Confirmatory test on sterilized ampoules

Ampoules that were adequately sterilized after incubation were confirmed only at 121  $^{\circ}\text{C}$  using the same procedures as in the first sterilization. The minimum processing time was 15 minutes while 60 minutes was the maximum processing time. The results in Table 13 show that adequate sterilization can be achieved at 121  $^{\circ}\text{C}$  for 15 minutes and beyond for canned minced grasscutter meat.

**Table 13: Confirmatory test at 121 °C**

Time (minutes)	Temperature (121 °C)
15	×
20	×
25	×
30	×
45	×
60	×

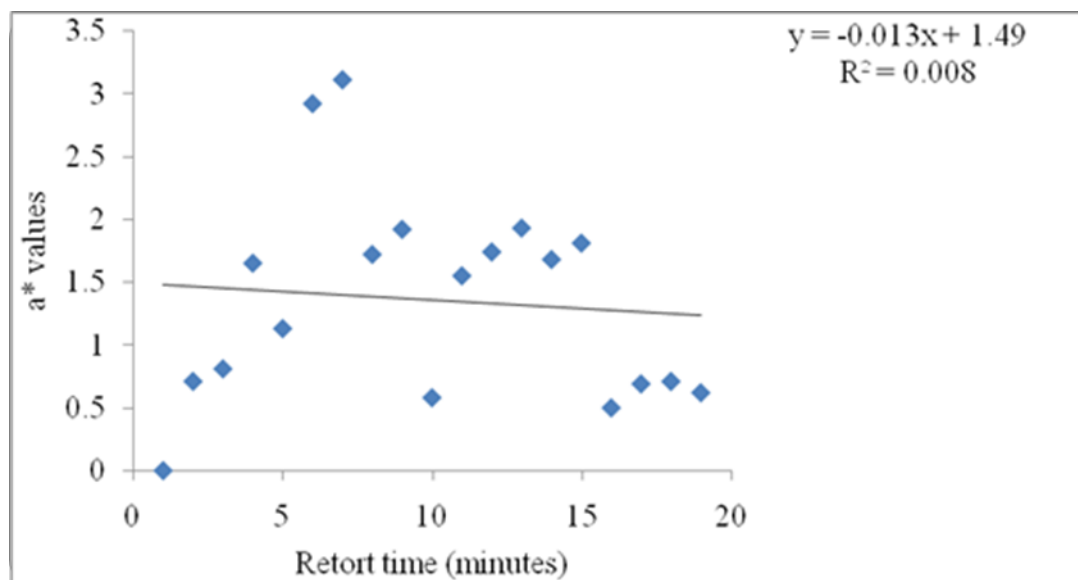
Figure 5 shows total colour change between retorted and unretorted minced canned grasscutter meat retorted at varying times at 121 °C. Total colour difference is a measure of the extent of colour change between the retorted and unretorted minced grasscutter meat. The values were obtained from the measured L\*a\*b\* between the retorted and unretorted (control) minced grasscutter.

**Figure 5: Total colour difference of canned minced grasscutter meat**

From figure 5, increase in time at constant temperature shows increase in colour contrast at a rate of 0.06 per unit time. Holdsworth (1985) and Awuah *et al.* (2007) reported that

optimum colour difference of product is obtained at higher temperature at a shorter processing time.

Figure 6 illustrate the effect of varying retort time on redness of minced canned grasscutter meat. There is a gradual decrease in the redness of minced canned grasscutter meat as retort time increases. The rate of decrease in redness of the product is -0.01 per unit retort time. Any thermal treatment has effect on the product being heated. Hur *et al.* (2009) reported that that the decrease in  $a^*$  of muscle fibres is associated with the gradual formation of metmyoglobin which gradually led to the discoloration of the minced product.

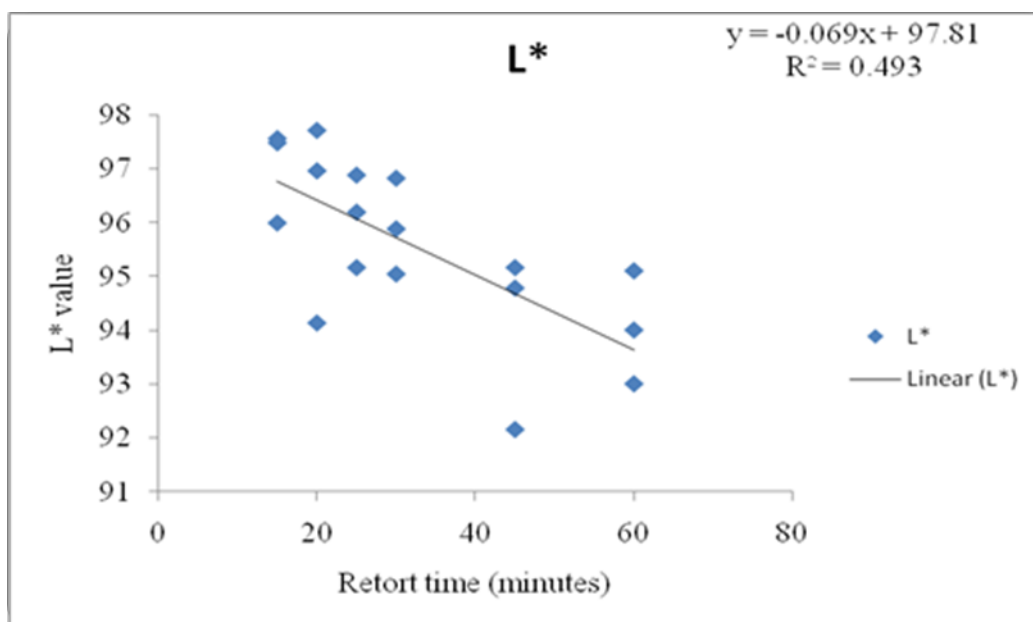


**Figure 6: Change in redness ( $a^*$ ) of canned minced grasscutter meat**

When there is a decrease in  $a^*$  value of meat products, it often reflects a decrease in the relative content of oxymyoglobin and a simultaneous increase in the relative content of metmyoglobin. A decrease in  $a^*$  value also causes a decline in both chroma and hue angle at the same time (Karamucki *et al.*, 2011).

O'Sullivan *et al.* (2002) indicated, that the colour parameter  $a^*$  value usually was tightly connected with content of oxymyoglobin in meat. Therefore it is possible to conclude, that after heat treatment due to metmyoglobin formation colour parameter  $a^*$  value decreases in meat. As a result meat colour turn to brown or grey-brown.

In Figure 7, the lightness of the minced grasscutter consistently decreased as processing time increased. The decrease in lightness of the meat is due to the reaction of the proteins with heat which resulted in darkening of the retorted meat. The linear equation ( $y = -0.0696x + 97.818$ ) describes the relationship between lightness of canned minced grasscutter meat and retort times (minutes). The rate of change in the lightness of canned minced grasscutter meat per unit processing time is about -0.07. The R-Squared of about 50.0% explains the extent of variability in Lightness of the canned minced grasscutter meat.



**Figure 7: Change in lightness ( $L^*$ ) of canned minced grasscutter meat**

Colour of meat is determined by myoglobin content in the meat. It is a heme iron pigment protein that binds water, oxygen and Carbon dioxide together (Mancini and Hunt, 2005).

Discoloration is a sign of spoilage. Many consumers purchasing decisions are based on the colour of products (Kropf, 1980). Decrease in lightness of cooked meat product is due to denaturation of myoglobin in the samples as temperature increases (Bernofsky *et al.*, 1959). Colour of meat is an important quality characteristic. During storage the changes in the colour of meat along the storage period defines its eating quality (Lindahl *et al.*, 2001). Kortz (1970) established that determining the change in colour of meat is a function of meat quality.

Colour perception plays a major role in the evaluation of meat quality as consumers use the colour as an indicator of freshness and it strongly influences the consumer's purchase decision. Colour of meat that is not red and bright is seen by consumers as meat of poor eating quality. Consumers therefore make purchase decisions strongly on colour. All the same meat colour is a poor guide to eating quality despite its strong appeal to consumers during purchasing (Young *et al.*, 1999). When meat is stored, a lot of changes take place in the meat system. These changes are reflected in many characteristics such as colour, tenderness, flavour and juiciness. During storage, the distribution and display, the processes of oxygenation and oxidation of myoglobin influence colour.

#### **4.3 Seamed cans examination**

The seamed cans were examined both externally and internally and measurements done to determine the success of the seam. Percentage hook overlap was calculated (56%) using body hook length, cover hook length, seam length, end plate thickness and body plate thickness of the can. The calculated percentage value (56%) exceeded the percentage value of a properly formed seam (55%).

#### 4.4 Sterilization values ( $F_0$ ) determination

The  $F_0$  value or sterilization value at the center of a product being heated is the total integrated sterilizing value for the product in the container (Stumbo, 1973). The concept of the F-value of a thermal process is the foundation of thermal process calculations. The F-value of a process is defined as the equivalent time of a hypothetical thermal process at constant temperature,  $T_{ref}$ , that produces the same result, as far as the destruction of microorganisms or other spoilage agents is concerned, with the actual thermal process, during which product temperature can be, and usually is, non-constant.

**Table 14: Sterilization values achieved for different times at 121°C**

Processing time (minutes)	$F_0$ (minutes) at the centre of product in can	$F_0$ (minutes) for heat distribution in canner
15	9.42	11.95
60	47.71	50.10

Developing any thermal process is based on the lethality of the target organism at the cold point or the slowest heating point of the cold product in the container being heated. The lethality of the thermal process can be calculated by determining the process lethality/sterilizing value which is defined as the time in minutes required to cause log<sub>10</sub> reductions in bacterial load at a given reference temperature (Aguilar-Rosas *et al.*, 2007). Critical indices for calculating thermal process lethality are  $D$  and  $z$ . A 12 D cycle is recommended for low acid canned foods to achieve a sterilization value of 3.0 minutes for *Clostridium botulinum* (Awuah *et al.*, 2007).

The objective for every thermal treatment is to inactivate microorganisms in a food system. However severe heat treatment can affect the quality of the food being thermally

processed. There is possible destruction on the sensory properties of the food and other nutrient losses (Awuah, *et al.*, 2007). Optimizing the thermal process while ensuring quality safe food is necessary since degradation of quality of food and microbial inactivation in any thermal process doubles for every 10 °C rise in temperature. Optimum product quality is however achieved at high temperature short time process schedules (Holdsworth, 1985).

In table 14, the sterilization value was lower in the 15 minutes processing time than that of the 60 minutes processing time at constant processing temperature. However, both set points sterilization values were higher than the target sterilization value for *Clostridium botulinum*.

#### **4.5 Quality attributes evaluation of canned minced grasscutter meat**

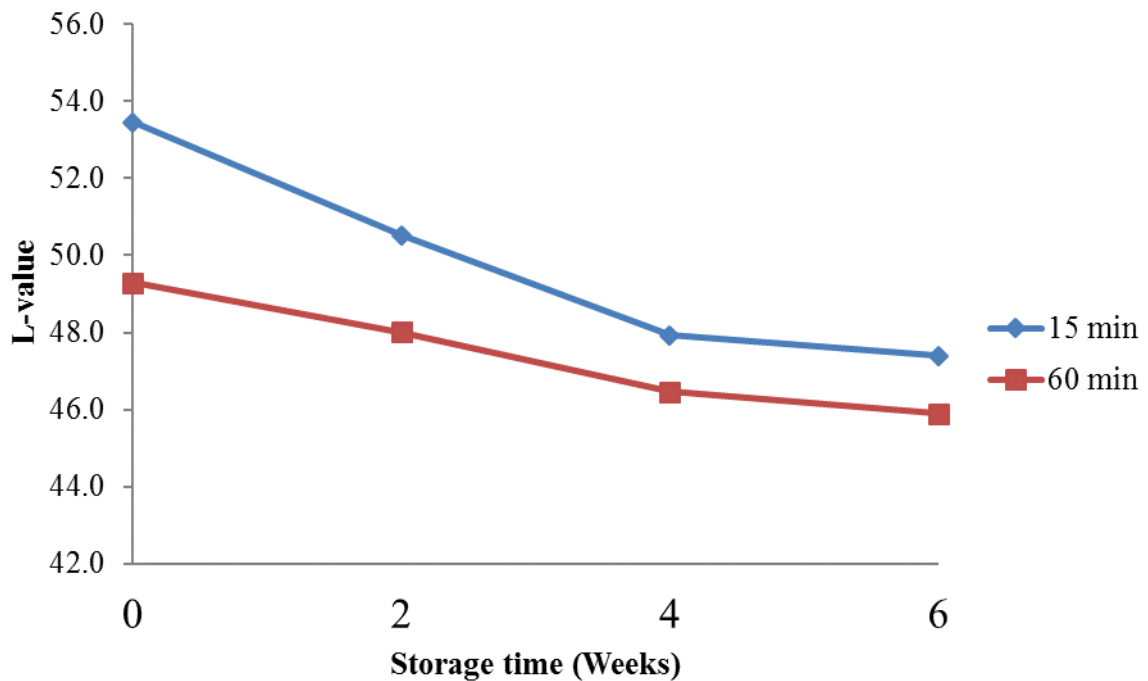
Consumers of food products have gained more knowledge and understanding on the safety, quality and sensorial characteristics of marketable products. Food manufacturers need to understand the demand trends of consumers. The study of consumer responses on the sensory attributes of food in relation to senses of sight, hearing, smell, taste and touch on the physical attributes of food is termed as sensory science. Sensory science scientifically stimulates, measures, analyses and interprets the psychological responses to physical stimuli. In general sensory science belongs to the fields of psychophysics (Hashmi, 2007). Table 15 shows the results on sensory attributes of canned minced one year old male grasscutter.

**Table 15: Assessment of canned minced grasscutter acceptability**

7-point hedonic scale	Sensory attributes (%)						Overall acceptability
	Colour	Taste	Juiciness	Texture	Flavor	Aroma	
Like Extremely	10	12	8	6	14	8	22
Like very much	48	36	42	32	8	20	46
Like slightly	8	14	24	18	18	10	20
Neither like nor dislike	18	30	22	26	48	44	6
Dislike slightly	8	6	2	10	8	10	2
Dislike very much	6	2	2	4	4	8	4
Dislike extremely	2	-	-	4	-	-	-

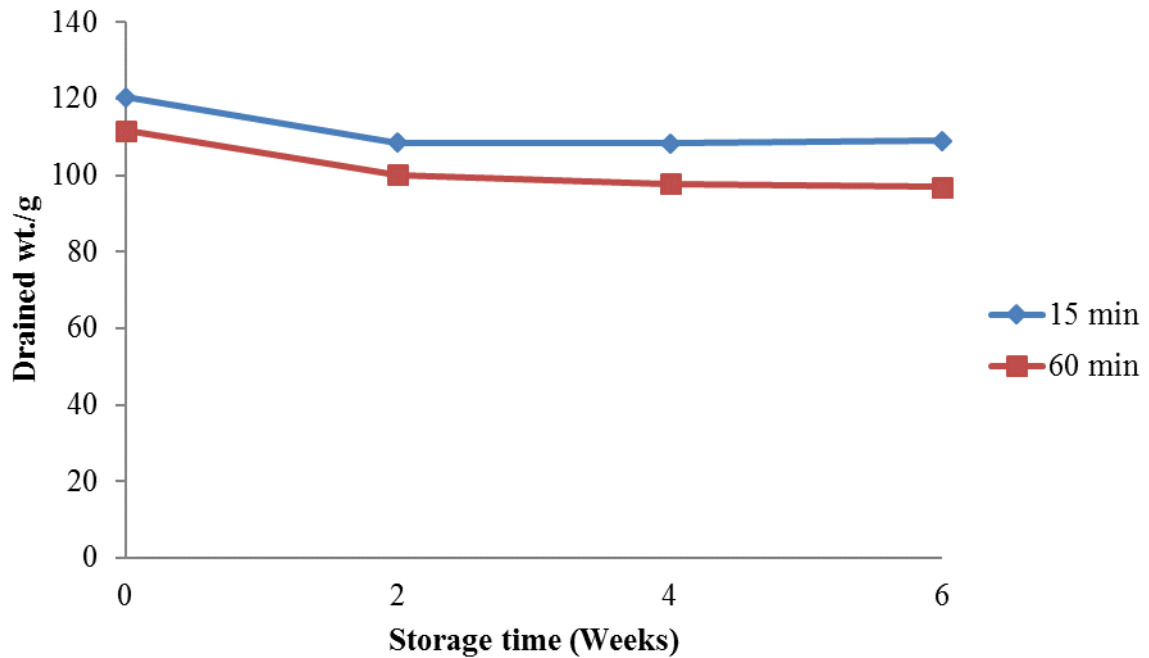
Panelists rated the product as like very much for colour, taste, juiciness and texture. Panelists however neither like nor dislike the aroma and flavor of the product. This may be due to the use of only brine as the media. Consumers are likely to accept the aroma and flavor when filling ingredients are used as media. Generally, the overall response on product was acceptable.

#### 4.6 Quality changes in canned minced grasscutter meat after storage



**Figure 8: Changes in L\*-value of canned minced grasscutter after six weeks storage**

In Figure 8, it can be observed that the colour of canned minced grasscutter decreased slightly within the first four weeks of storage at both processing times. The L\* showed consistently lower values as the processing time increased at 121.1 °C. These observations suggest that the colour of canned minced grasscutter was affected by the thermal processes. The L-value assumed a constant trend after the fourth week. However, the L-value was lighter at the 15 minutes processing time than that of the L-value at 60 minutes processing time. The decreasing L\* values shows that the product was becoming darker with increase in processing time. The dark colour of the product is as a result of non-enzymatic browning (Maillard reactions) in the product. Protein foods often undergo Maillard reactions and a possible loss of some amino (Awuah *et al.*, 2007).



**Figure 9: Changes in drained weight of canned minced grasscutter after six weeks storage**

The drained weights of canned minced grasscutter were obtained after draining off the media for two minutes through a sieve and the resultant product considered as the drained weight of the product. Figure 9 shows the drained weights of canned minced grasscutter stored for six weeks at  $27 \pm 2$  °C. There was a marginal decrease in drain weight in the first two weeks of storage and then flattens off in the rest of the storage period. However, there was higher drained weight of minced grasscutter meat when the product was retorted for fifteen minutes than when it was retorted for sixty minutes. This could be as a result greater of loss of fluid in the product retorted for sixty minutes as compared to the product retorted for fifteen minutes. This shows that higher processing times will yield lower drained weight than shorter processing time at same temperature. It is therefore economical to process the product at shorter time.

**Table 16: TBARS of stored canned minced grasscutter**

Storage time (weeks)	Retort time/min			
	15		60	
	Absorbance (nm)	Concentration (mol/dm <sup>3</sup> )	Absorbance (nm)	Concentration (mol/dm <sup>3</sup> )
2	0.043	$-2.0 \times 10^{-8}$	0.044	$-1.4 \times 10^{-8}$
4	0.044	$-1.4 \times 10^{-8}$	0.048	$1.0 \times 10^{-8}$
6	0.043	$-2.0 \times 10^{-8}$	0.050	$2.3 \times 10^{-8}$

*Storage temperature = 27 ± 2 °C.*

Meat that is stored is often liable to oxidation of the lipids and the proteins in the meat. Oxidative process often leads to changes in the quality of the meat due to the formation of compounds that causes off-flavours in the stored meat. These off-flavours affect the eating quality of meat (Asghar *et al.*, 1988). The determination of meat quality through oxidative processes is affected by the length of time the meat is stored as well as the temperature at which the meat has been stored (Tan and Chen, 2005), and also the presence of oxygen.

Results on TBARS analyses are presented in Table 16. TBARS value gradually increased with storage periods for both retort times. TBARS values of samples retorted for 60 minutes were higher than TBARS values retorted for 15 minutes. However, the concentrations of TBARS are negligible for both 15 and 60 minutes. Lipid peroxidation is a leading cause of quality deterioration in meat and meat products. In this study, negligible TBARS values were found in 27±2°C storage samples for both retorting times at 121 °C. Grasscutter meat has low cholesterol and may account the very low oxidation during the storage period.

## CHAPTER FIVE

### 5.0 CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

The following conclusions were derived from the study:

- i. Grasscutter meat was the most preferred among other meats and meat products such as chevon, beef, fish, mutton and eggs. The consumers' age, marital status and number of dependents were significantly ( $p \leq 0.05$ ) associated with preferred methods of cooking grasscutter meat. Majority of the younger age group preferred smoked grasscutter meat. Respondents who were single or married with two children as well as those with two dependents also preferred smoked grasscutter meat. The cost and availability of grasscutter were limiting factors to the consumption of grasscutter meat and they were significantly associated with the marital status of respondents.
- ii. Sterility of canned minced grasscutter meat was achieved ( $F_0 = 9.47$ ) at minimum time of fifteen minutes at  $121.1^\circ\text{C}$  which is higher than commercial target  $F_0$  of 3.0 for the inactivation of *Clostridium botulinum* spores. Incomplete sterilization occurred at temperatures below  $116^\circ\text{C}$  for 15, 20, 25, 30 and 45 minutes.
- iii. Canned minced grasscutter meat was acceptable to consumers. There were high scores for texture, colour and juiciness for canned minced grasscutter meat. Panelists however neither like nor dislike the aroma and flavor of the product. This may be due to the use of only brine as the media.
- iv. Canned minced grasscutter maintained its sensory qualities during six weeks storage at room temperature. Accumulation of Thiobarbituric Reactive Substances were also minimal during the storage period.

## 5.2 Recommendations

It is being recommended that

- i. Research Institute, government, non-governmental organization and business interest should intensify training on grasscutter rearing since it is the most preferred meat and eating by all age groups.
- ii. An extended shelf life study should be conducted to measure the sensory attributes along storage time.
- iii. Since panelists neither like nor dislike the flavour and aroma of canned minced grasscutter, filling ingredients such as tomato sauce, oil, and vegetable can be used in canned minced grasscutter to obtain further information on its flavour and aroma.
- iv. Commercialization of canned minced grasscutter should be encouraged as a healthy source of animal protein since very low TBARS values were recorded during storage.

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## APPENDICES

## Appendix 1: Demographic characteristics of respondents

Table 1: Preferred method of preparing and cooking grasscutter meat on age group of Respondents

Preferred method of preparing and cooking grasscutter meat by respondents	Age group of respondents							Total
	<20	21-30	31-40	41-50	51-60	61-70	>70	
Drying	2	4	2	4	2	0	0	14
Smoking	2	23	29	24	14	0	0	92
Roasting	1	8	7	2	1	1	0	20
Frying	3	7	9	3	3	0	1	26
Grilling	1	14	3	1	1	0	0	20
Boiling	4	13	6	4	1	0	0	28
<b>Total</b>	13	69	56	38	22	1	1	200

Table 2: Preferred method of preparing and cooking grasscutter meat on marital status

Preferred method of preparing and cooking grasscutter meat by respondents	Marital status					Total
	Single	Married	Separated	Divorced	Widowed	
Drying	7	6	0	1	0	14
Smoking	31	50	4	3	4	92
Roasting	8	10	0	2	0	20
Frying	6	16	1	1	2	26
Grilling	15	2	2	0	1	20
Boiling	17	7	1	2	1	28
<b>Total</b>	84	91	8	9	8	200

**Table 3: Preferred method of preparing and cooking grasscutter meat on number of dependents**

Preferred method of preparing and cooking grasscutter meat by respondents	Number of dependents										Total
	2	3	4	5	6	7	8	9	10	13	
Drying	7	0	3	1	1	1	1	0	0	0	14
Smoking	23	8	10	8	13	9	13	5	3	0	92
Roasting	6	3	7	2	0	1	1	0	0	0	20
Frying	6	4	6	4	2	0	3	0	0	1	26
Grilling	16	0	1	0	1	1	0	1	0	0	20
Boiling	13	3	4	3	2	0	2	1	0	0	28
Total	71	18	31	18	19	12	20	7	3	1	200

**Table 4: Frequency of consumption of grasscutter meat on marital status of respondents**

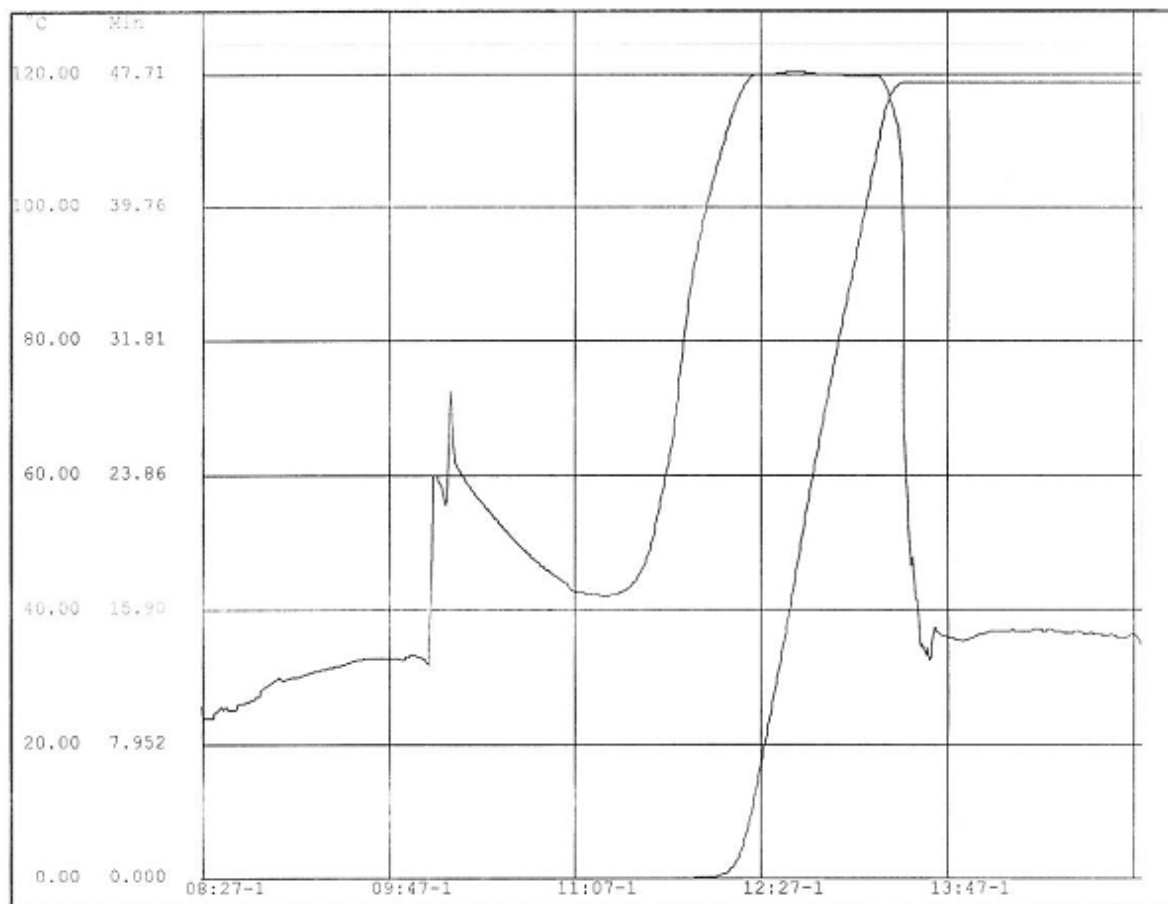
Frequency of consumption of grasscutter meat	Marital status					Total
	Single	Married	Separated	Divorced	Widowed	
Every week	2	18	0	0	0	20
Every month	24	26	4	3	4	61
Occasionally	58	47	4	6	4	119
Total	84	91	8	9	8	200

**Table 5: Frequency of consumption of grasscutter meat on number of dependents**

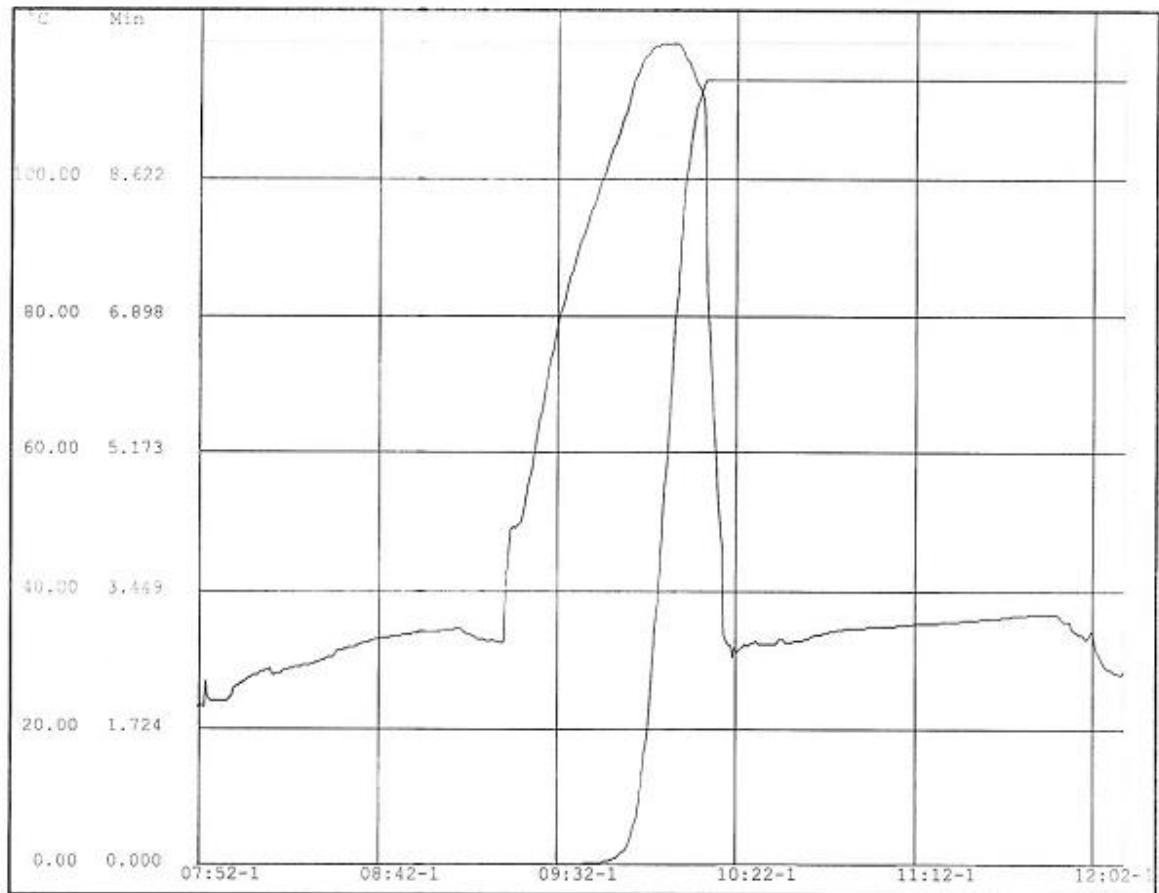
Frequency of consumption of grasscutter meat	Number of dependents										Total
	2	3	4	5	6	7	8	9	10	13	
Every week	2	0	5	3	3	5	0	2	0	0	20
Every month	19	5	7	6	10	2	9	2	1	0	61
Occasionally	50	13	19	9	6	5	11	3	2	1	119
Total	71	18	31	18	19	12	20	7	3	1	200

Factors that limit consumption of grasscutter	Marital status					Total
	Single	Married	Separated	Divorced	Widowed	
Cost of grasscutter meat	46	51	4	3	4	108
Grasscutter meat availability	42	39	5	5	3	94
Ebola Scare	6	6	0	1	1	14
Chemical Contamination	0	1	0	1	0	2
Total	94	97	9	10	8	118

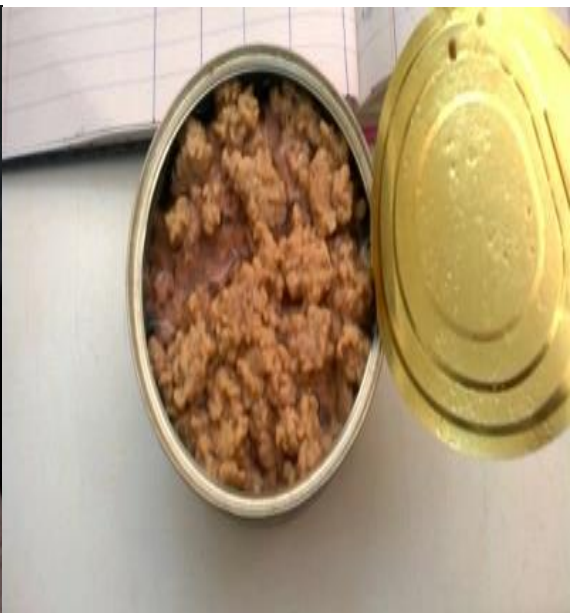
Multiple responses (N = 200)

**Appendix 2: Product heat penetration curves****Figure 1: Product heat penetration curve during 60 minutes sterilization**

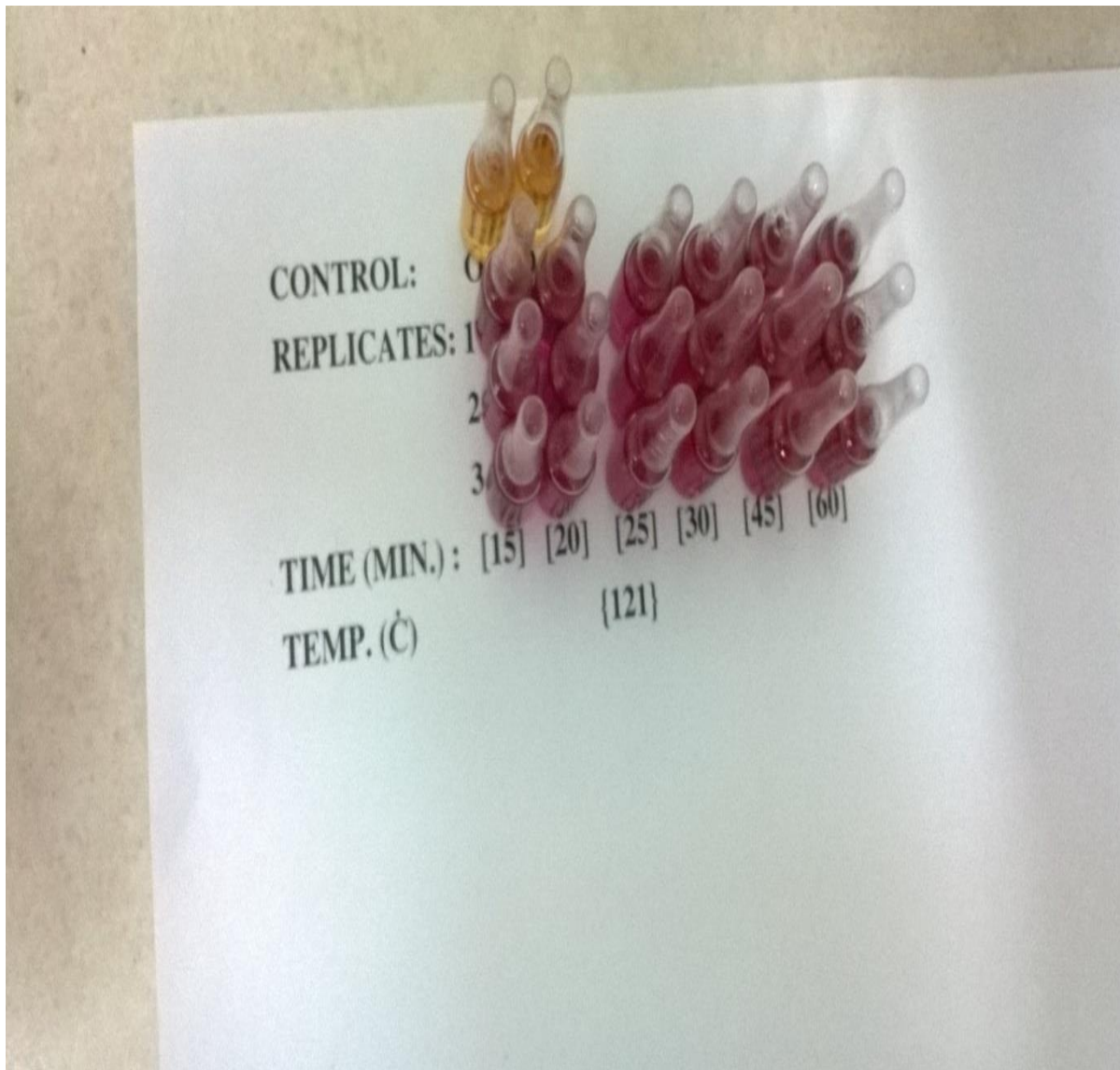
**Figure 2: Product heat penetration curve during 15 minutes sterilization**



**Appendix 3: Carcass and canned minced grasscutter meat**



**Appendix 4: Colour development after incubation for 48 hr at  $60 \pm 2$  °C**



## Appendix 5: Sensory ballot and questionnaire

### 1. Quality attributes description chart

#### Quality attributes description chart for minced canned grasscutter meat.

Please read and understand the attributes before answering the statements rated in the hedonic scale.

Quality attribute	Quality attribute instruction
Colour	You are presented with a sample of minced canned grasscutter meat. Look carefully at the sample and rate the product using the scale
Aroma	Please sniff the sample and rank the product on the scale provided
Juiciness	Chew the sample slowly. The release of liquid from the samples gives impression of juiciness
Flavor	A distinctive taste couple with scent while sample is slowly chewed gives indication of flavor
Taste	Sweetness of sample is an impression of taste
Texture	How easily the sample breaks (tenderness) or how difficult it is to chew (toughness) is an impression of texture
General acceptability	Satisfaction achieved of samples evaluated
Cost of product	Cost the product comparable to corned beef in the market. Assume the corned beef occupies same space as in the can before you. (NB: Mean drained weight = 120.00g)

### 2. Sensory Questionnaire

**TICK YOUR RESPONSE FOR EACH ATTRIBUTE USING THE SCALE PROVIDED**

**Colour:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike; 5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Taste:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike;  
5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Aroma:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike;  
5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Juiciness:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike;  
5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Flavour:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike;  
5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Texture:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike;  
5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Overall acceptability of meat:** 1-Like extremely; 2-Like very much; 3-Like slightly; 4-Neither Like nor Dislike;  
5-Dislike slightly; 6-Dislike very much; 7-Dislike extremely

**Cost of product.....Age.....**

**Gender.....Comment.....**

#### **Appendix 6: Assessment of consumer demands of grasscutter meat sold in restaurants and chop bars in Ga-West Municipality**

Nutrition and Food Science Department

P.O.Box LG 134

Tel: 0246856786

0207452002

Dear Sir/Madam

### **Research on Consumer Preference for Grasscutter Meat**

This research project questionnaire seeks to assess demands, habits and preference for grasscutter meat. The researchers kindly request that you complete this questionnaire regarding your habits, preferences and demand for grasscutter meat.

The data provided will be held confidential by the researchers. Your name or other identifying information will not be associated with the data or any reports or presentation derived from the data. To ensure anonymity, please do not enter your name or contact details on the questionnaire. Your responses will be used for academic purposes only.

Sincerely,

Dery Titus S.S.

### **SECTION A**

**PERSONAL DETAILS OF RESPONDENTS (PLEASE TICK WHERE APPROPRIATE).**

**This section will enable the grasscutter researchers compare groups of respondents. The information you provide will be kept confidential. Your name or other identifying information will not be associated with the data you provide. Your data will be coded with a random numerical code to ensure your privacy.**

1. Gender  Male  Female
2. Age group  Below 20  21-30  31-40  41-50  51-60  61-70  Above 70
3. Region and Home Town
4. Religion  Christian  Muslim  Traditional  Other, please specify:
5. Marital status  Single  Married  Separated  Divorced  Widowed
6. How many dependents do you have?
7. What is your highest educational qualification?
- None  Basic Education  Senior high school  Tertiary Education

## SECTION B

**This section assesses your preference, buying habits and demand for grasscutter meat**

8. What is your preferred method for cooking and preserving grasscutter meat?

Drying  Smoking  Roasting  Frying  Grilling  Boiling

9. How often do you eat grasscutter meat?

Every day  Every week  Every month  Occasionally

10. What limits your consumption of grasscutter meat?

11. On the average how much do you buy one cooked piece of grasscutter? Values are in

GH¢.

Below 3.00

3.00-4.99

5.00-6.99

7.00-9.99

10.00-15.00

Above 15.00

12. How important are each of the following to you when buying grasscutter meat? Please circle the number that best represents your answer in each row in the table below using the following 5 point scale; where

1 = Totally unimportant

2 = Unimportant

3 = Neutral

4 = Important

5 = Very important

	Totally unimportant	Unimportant	Neutral	Important	Very important
Price of the meat (Affordability)	1	2	3	4	5
Choice cut (part preferred)	1	2	3	4	5
Taste	1	2	3	4	5

Nutritional knowledge of the meat	1	2	3	4	5
Processed (smoked)	1	2	3	4	5
Freshness	1	2	3	4	5

13. Do you prefer grasscutter meat over other meat and meat products?  Yes  No

14. Provide reasons for your answer in question 14 in the box below.

15. Rank in order of preference from **1** to **6** with **1** being most preferred and **6** being least preferred for the following protein sources;

**Grasscutter meat, Goat meat, Beef, Fish, Chicken, Eggs**

- 1.....
- 2.....
- 3.....
- 4.....
- 5.....
- 6.....

**SECTION C**

**The following questions pertain to your acceptance to value addition of grasscutter meat.**

16. Would you consider purchasing processed canned grasscutter meat?  Yes  No

17. If your answer to question 17 is **yes**, what forms of processed grasscutter meat would you like to purchase?

18. If you answered **No** to question **17**, please provide reasons for your answer in the box below.

19. Rank the following processed grasscutter meat in order of preference with **1** being most preferred and **5** being least preferred.

<b>Processing and preservation method</b>	<b>Rank</b>
Canned grasscutter meat (chunks pieces)	
Corned grasscutter meat (like corned beef)	
Vacuum packed grasscutter meat	
Smoked grasscutter meat	
Dried grasscutter meat	

20. Give reasons for your order of preference in question 20

Thank you very much for your responses.