UNIVERSITY OF CAPE COAST

EFFECTS OF SMOKING ON THE QUALITY ATTRIBUTES OF SHRIMPS IN GHANA

AGNES ABANKWAH

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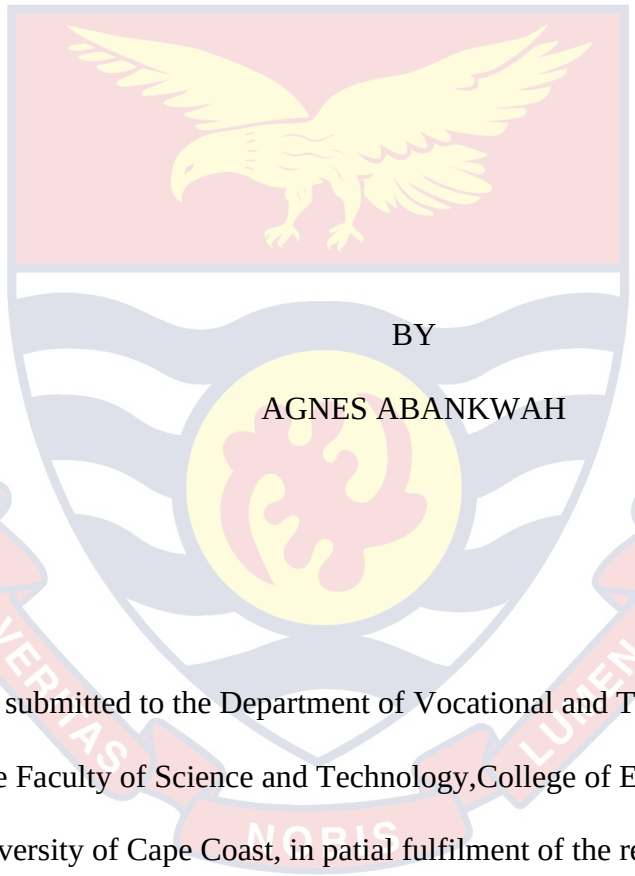

BY

AGNES ABANKWAH

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OCTOBER 2021

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ……. Date ……..

Name: Agnes Abankwah

Supervisor's Declaration

I hereby declare that the preparation and presentation of this thesis were supervised in accordance with the guidelines on supervision of the thesis laid down by University of Cape Coast.

Supervisor's Signature …… Date ……

Name: Dr. Augustina Araba Amissah

ABSTRACT

The study assessed the effects of smoking on the quality attributes of *penaeus notialis* shrimps in Ghana. *Terminalia ivorensis*, *Petersianthus macrocarpus* and *Albizia zygia* were used as fuel woods to smoolder the shrimps. Four research objectives and two hypotheses were used to find solution to the research problem. Theoretical, empirical and conceptual framework were used shape the study. Descriptive and experimental research designs were adopted to guide the entire study. Frequency and percentage were used to analyse the background information of the respondents. In the case of research objectives and the hypotheses, one way Analysis of variance (ANOVA) was used to test for significant differences among the types of wood used and consumer's preferences. The study revealed that seven nutrients (Dry Matter, Moisture, Ash, Protein, Fibre, Fat/Oil and Carbohydrate) found were significant. Also, the fuel used for the smoking did not have any negative effect on the nutrients in the smoked shrimps. The study further showed that panelists accepted 'USAZ' formulation as the most preferred product with a mean score of 4.11. Also, 'PSAZ' formulation was also most preferred with a mean score of 4.14. There is a significant difference in the types of wood used for smoking with regards to nutritional and chemical properties of the shrimps. The study further found a significant difference on shrimps smoked with selected wood types for smoking and consumers preference. The study therefore, recommended that, the use of a particular wood type would encourage the consumption of smoked shrimps due to its flavour or aroma, colour,texture and even the taste.

KEYWORDS

Shrimps

Smoking

Nutreints

Quality

Attributes

Sensory evaluation

Fuel wood

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DEDICATION

To my husband Mr. Daniel Osei Boamah and children Melvin, Lillian and Caroline.

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LIST OF ACRONYMS

CAC Codex Alimentarius Commision

FAO The Food and Agricultural Organization

GSS Ghana Statistical Service

INFS Institute ofNutrition and Food Science

IFT Institute of Food Technology

IOM Institute of Medicine

KMA Kumasi Metropolitant Assembly

CHAPTER ONE

INTRODUCTION

Background to the Study

Since prehistoric days, food preservation has been used; the preservation process would hamper the growth of microbes such as bacteria and fungi (Seetaramaiah, Smith, Murali & Manavalan, 2011). Food preservation increases food shelf life and maintains food quality by controlling food enzymes or chemically active compounds, controlling the mechanism of microbial degradation and preventing defective post-harvest handling activities (Adegoke & Olapade, 2012). Food preservation goals include the conservation of food taste , texture, flavor, consistency and nutritive quality, the elimination of unnecessary food waste, the prolongation of shelf life, fast transport and food handling (Devi, Bhowmick, Bhanusree & Ghosh, 2015).

There is an increasing interest from customers for marginally treated seafood that preserves its sensory and nutritional characteristics after management and packing. Yet, during processing and storage, consistency loss of seafood happens soon after death, and is connected with enzymatic, microbiological as well as chemical reactions (Olatunde & Benjakul, 2018). Numerous synthetic additives (preservatives) are appealing to prevent changes in texture and colour, undesirable taste and malodorous scent growth, and loss of seafood nutrients during low temperature stockpiling to preserve consistency (Olatunde & Benjakul, 2018). Using these preservatives, though, has been correlated with possible wellbeing risks. In such manner, with the primary intention of enhancing shelf-life, organic additives with outstanding antioxidant and antimicrobial abilities have been broadly looked at for and applied as safe

substitutes in seafood production (Olatunde & Benjakul, 2018). Commonly used natural preservatives encompass plant extracts, bacteriocins, bioactive peptides, chitosan and chitooligosaccharides, and vital oils, among others (Olatunde & Benjakul, 2018).

In 2002, 133.0 million tonnes of total world fishery output (excluding aquatic plants) were recorded, of which 41.9 million tonnes were from aquaculture activities. The production of world catch fisheries amounted to 93,2 million tonnes, reflecting a marginal rise of 0,4% relative to 2001 (Vannuccini, 2004). In Africa, nearly 5 % of the population, or roughly 35 million people, relies entirely or partially on the fisheries industry , mainly artisanal fisheries, for their livelihoods (FAO, 2001). Three percent of the national Gross Domestic Product is contributed by the fisheries industry in Ghana. Around 2 million Ghanaians, comprising 860,000 females and 1,140,000 males, are projected to be working or reliant on activities in the sector (GSS, 2019).

Shrimps belong biologically to a large number of crustaceans with an expanded belly. They constitute one of the third most respected commercial seafood products (Oosterveer, 2006). They have acquired quite enough fame in Ghana and Africa in general, so they are fished within Africa's coastal regions on both commercial and artisanal scales (Entsua-Mensah, De Graft-Johnson, Atikpo, & Abbey, 2002). It is known that shrimps produce almost 20% protein with well-balanced amino acids and substantially large levels of other nutrients, along with calcium and selenium micronutrients.

Shrimp lipids are typically composed of polyunsaturated unsaturated fats that are vital to human wellbeing (Sriket, Benjakul, Visessanguan & Kijroongrojana, 2007; Yanar & Celik, 2006). They have additionally been

established as abundant in vitamin B_{12} and astaxanthin, a fat-soluble carotenoid which has antioxidant qualities (Venugopal, 2008). Owing to seasonal variables such as climate conditions, geographical factors, habitat, stage of development, sex and sexual maturation, the proximate composition of shrimps, crustaceans and other marine species has been shown to be diverse.

Crustaceans are important food source; species such as lobsters, shrimps, prawns and crabs have become economic spieces with some harvested from the wild stocks and others being farmed (FAO, 2018; 2016; 2014). Shrimp is the most important seafood product traded internationally. Out of 59.9 million tonnes of farmed food fish produced in 2011, crustaceans constituted 5.7 million tonnes accounting for 9.5 percent of global aquaculture production (FAO, 2012). In 2012, crustaceans contributed nine point seven percent (6.4 million tonnes) and 22.4 percent by value (FAO, 2014). In 2014 crustacean production was 6.9 million tonnes contributing 9.3 percent out of the 73.8 million tonnes of total global aquaculture production (FAO, 2016). Production of the crustaceans increased to 7.8 million tonnes constituting 9.6 percent of the 80.03 million tonnes produced in 2016 (FAO, 2018). Crustacean production could be crucial in contribution to livelihood and income for people engaged in the aquaculture sector (Chauvin, 1986; FAO, 1998), being roughly 20% of the overall volume of the globally traded fishery items FAO (2000).

Interest in and understanding of human nutrition has brought out a few questions concerning the high incidence of chronic diet-related diseases in the world's developed and developing countries. Actively choosing foods for nutritional restoration and disease prevention has now been essential to shoppers. Epidemiological surveys have found that there are low incidences of

heart attacks in certain communities that primarily eat seafood (Hu, Bronner, Willett, Stampfer, Rexrode, Albert & Manson, 2002; Willet, 2007).

Seafood is nutrient-rich and supplies high-quality protein, as per the Institute of Medicine (IOM, 2006) study, and also may be utilized to solve the problems of protein malnutrition in Sub-Saharan Africa, because protein supplements are not sufficient among individuals. As Akonor, Ofori, Dziedzoave and Kortei (2016) affirmed, dehydrated shrimps are prominent and generally appropriate in Ghana as they are being utilized as a primary wellspring of protein and for their delectable flavour (in entire or powdered structure) in soups and sauces.

Food quality requirements have been an exceedingly critical concern for global trade in agriculture and food goods in recent decades (Jaffee & Henson, 2004). Buyers and regulators have gotten more mindful of the dangers involved with food safety and require safe food handling (Unnevehr, 2000; Ko, 2010). The Food and Veterinary Office (FVO) of the European Commission has set out some teams to all trading nations to determine the healthful situations through which fishery products destined for export to the European Union are being made, in order to guarantee the imports of fishery products into the European Union. The FVO experts discovered in 2002 that the shrimp harvesting network from the arrival destinations to the handling facilities in Ghana was never well planned and that the HACCP strategies at the factories were not brought to bare. Ghana, however, did not have the legislative framework to guarantee the consistency and welfare of shrimp (FVO, 2003). In response to the findings of the FVO technical inspection, as a safety measure, the central government agreed to autonomously forbid the export of shrimp.

Shrimps were one of Ghana's key exported employment and income producing products; the restriction led to work loss of 60,000 and a loss of revenue of about 10 million euros between 2003 and 2006 (Le Ry, 2007). In 2005, the law was repealed. However, upon their subsequent visit in 2009, the specialists of the FVO found that only the Ghanaian policy could be deemed to be equal to the feed and food regulation of the European Union; shortcomings relevant to the management of shrimp quality existed.

Fish is a very short-lived food product exceptionally powerless to decay with no additive or handling measures. The level of decay of the fish is influenced by the processing and storage procedure after catch (Akinneye, Amoo & Arannilewa, 2007). The Right pre-treatment or handling of fresh fish of premium quality will mitigate after-harvest losses and thereby decrease the incidence of spoilage of the fish. Spoilage occurs as a progression of complex enzymatic, bacterial and compound variations which, based on the species and the predominant encompassing temperature, begin within a few hours after fish are captured (Tawari & Abowei, 2011).

Therefore, efforts should be directed at increasing fish production by enhancing stock management in combination with successful post-harvest storage, protection and processing to avoid spoilage (Okafor & Nzeako, 1985). Akande *et al.* (1998) testified that there were 40 percent post-harvest losses of total fish caught in Nigeria in 1997; 15 percent of the all out fish captured at Kanji Lake were lost on account of the decay and handling between the causes of distribution and utilizations. The catch should then be protected in chilly rooms until it is prepared for handling, so as to save the newness of the fish.

However, only heating can kill such bacteria (e.g. Salmonella), which live in freezers and brines (Bender, 1982).

To drag out the time span of the usability of fish, some protection techniques utilized in the tropics incorporates chilling, freezing, drying, salting and smoking. These methods preserve food by adding to the food products life span, maintain their appropreatness, maintain their phisical qualities and their taste (Akinola, Akinyemi, & Bolaji, 2006).

Smoking, since that is the key issue of this paper, can be achieved in a number of contexts: pre-drying or salting prior to actually smoking; cold-smoking involving the utilization of low-heat produced by fuel-wood and the goods produced may not last long; and hot-smoking involving the use of some more heat by the burning of substantial quantities of fuel-wood (Clucas, 1982). During smoking convention, on the off chance that the time, temperature and kind of wood is not being controlled and chosen according to the principles compound, physical and dietary content of smoked fish items will be influenced (Mojisola, 2014). By drying, frying as well as depositing natural wood-smoke chemicals such as tars, phenols and aldehydes, smoking protects fish, both of which have strong bactericidal activity and prohibit other micro-organisms from developing on fish flesh (Garrow & James, 1994).

Generally speaking, the retention effect is due to the anti-oxidant and antimicrobial effects of phenolic compounds. The major improvements in the organoleptic characteristics of fishmeal are also accounted for this mechanism (Kjallstrand & Petersson, 2001). For processors who want to tailor their goods to customer demand, the regulation of organoleptic qualities may be of real importance. Prior studies have demonstrated that the smoke age technology and

the smoking system utilized have a major effect on the sensory attributes of smoked fish, specifically on the impression of smoke flavour (Cardinal et al., 2006). However, the correlation between the sensory qualities and the chemical arrangement of smoked fish, in particular the composition of the odorant compounds emanated by smoke, was not permissible in these works.

There are also significant demands from EU organizations on the chemical quality of smoked goods. Thus, at its 29th meeting from 16 to 20 April 2007, the Codex Alimentarius Commission on Pollutants in Food formed a perspective on the reduction of quantities of polycyclic aromatic hydrocarbons (PAHs) in dried and smoked food. Likewise, EU Regulation 1881/2006 demands that a new, more rigorous law on the quality of PAH in smoked goods be formally created.

The role of PAHs, notably benzo[a]pyrene, has subsequently been documented in smoked fish (Simko et al., 2002), but there is little knowledge available on the effect of smoking methods. Some reports equate contemporary and conventional smokehouses (Karl & Leinemann, 1996; Karl, 1997) but, to our understanding, there really is no comparative study of new manufacturing fish smoking practices in relation to the 20 PAHs alleged of being carcinogens (European Commission, 2005). In addition, a liquid smoke atomization method has been introduced in recent years to decrease PAH quantities in smoked salmon.

Wood smoke is delivered by seething chips or sawdust of firm wood underneath the fish in the smokehouse (Visciano, Perugini, Conte, & Amorena, 2008). The organization of wood has an impact to the taste of the eventual outcome. Wood utilized as a smoke source is hardwood, for example, beech,

hickory, oak or fruitwood as apple, pear jackfruit, and so on. The taste of smoke exists throughout the amount of smoke in which the fish is covered (Anazonwu-Bello, 1976). Its color is determined by smoke, and is one of the traits that lure shoppers. The colour, taste / flavor and texture ultimately depend mostly on smoking process or the fuel type (wood) often used to smoke the fish (Essumang, Dodoo & Adjei, 2013).

Statement of the Problem

Fishery products are crucial foodstuffs for lots of customers in Africa; they are a big source of animal protein available to low-income households, particularly in places where meat prices are beyond the control of the average consumer (FAO, 2004; Lem, 2005; Anonymous, 2005a). About one-quarter of the world wide exported shrimp emerges from aquaculture, (27 - 29%), (FAO, 1998). This was however not enough to keep up with the growing demand for shrimp, the report indicated. There is also increasing emphasis on the nutritional benefits of eating seafoods. Shrimp hunting serves a major socio-economic part in Ghana, as completely new shrimp is among the country's most valuable export items (Horemans, 1998; Anonymous, 2005).

However, available literature indicates that there is information in the information on the effects of conventional strategies of fish conservation utilized to satisfy market needs. A portion of these protection techniques utilize extra food additives which can be grouped into artificial and natural additives yet conventional smoking cycle is managed without the expansion of additives (Ogbona & Ibrahim, 2009).

A portion of these cycles however significant for protection differently affect the physical, compound and nutritional organization of shrimps (Foline

et al., 2011), and there is expanding consideration on effects of safeguarding on wholesome characteristics of dietary fish (Eyo, 2001). Smoking of shrimps is done with different kinds of woods. However, the sort of nutritional and biological effect the woods have on the shrimps and its acceptability among the consumers has not been explored.

Indeed, in general, the atmosphere within which fresh shrimps are handled is unclean, setting the stage for future microbial contamination and food toxicants including histamine to be generated. Quality errors are the outcome of this, with periodic public health threats. There is, however, a risk for intermittent amine poisoning, considering a lack of knowledge on food poisoning triggered by shrimp in Ghana. No similar investigations of liquid smoke with conventional smoking procedures, applying wood pyrolysis, are accessible.

This research was therefore focused at offering a clearer interpretation of the techniques of protection and preparing of new shrimps, the varieties of crude materials and different ingredients involved with the handling of shrimp, and the description of the actors' most essential quality characteristics of fresh and processed shrimps. In simple terms, this study is aimed to evaluate smoking methods with different types of wood for preserving shrimps and its effects on nutritional, biological and the sensory properties of shrimps.

Purpose of the study

The purpose of the study is to evaluate smoking method on the quality attributes of shrimps.

Objectives of the Study

The objectives of the research are to:

i. assess the effects of smoking method on the nutritional value of shrimps.

ii. evaluate the effects of smoked shrimps using different type of woods.

iii. sensory evaluate the acceptability level of smoked and un-powdered shrimps with different kinds of wood.

iv. sensory evaluate the acceptability level of smoked and powdered shrimps with different kinds of wood.

Hypotheses

i. H_0: There is no significant difference between the types of wood used for smoking with regards to nutritional and chemical properties of shrimps.

H_1: There is significant difference between the types of wood used for smoking with regards to nutritional and chemical properties of shrimps.

ii. H_0: There is no significant difference between shrimps smoked with selected wood types for smoking and consumers preference.

H_1: There is significant difference between shrimps smoked with selected wood types for smoking and consumers preference.

Significance of the study

The findings from the study will add unto the existing knowledge on the effect of smoking, microbial activity, taste and sensory evaluation on shrimps. The finding would be of importance to the food industry in packaging the shrimps to last longer on the shelf. Those who prepare 'Shitto' on commercial quantity for sale will benefit from this study by knowing which wood when used to smoke shrimps is best accepted and have its nutritive value not destroyed.

Delimitation of the Study

The study will be limited in scope to some locally selected woods for fuel. The selected fuel woods are *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia) and *Albizia zygia* (Okro) in kiln or smoke houses. The sample is ruled predominantly by *P. notialis* despite the fact that there are other barely any assortments found in the populace, which were distinguished as *P. monodom* and *P. kerathucus*. The shrimp species for the study were *Penaeus Notialis* from the Cape Coast landing beach.

The smoking of the shrimps was done in Kumasi Asafo market. Data was on nutritional value, biochemical composition, types of wood used and sensory evaluation of the smoked shrimps using students from Department of Catering and Hospitality in Kumasi Technical University.

Limitation of the Study

The study has been a novel one since it involves the use of fire wood that are commonly used by local people to do their smoking of fish and shrimps. The literature in this direction of the study have been difficult. The literature became scanty of the fact that very few study has been done on shrimps smoking. Collection of data for the study has been a big challenge in view the outbreak of corona virus in the country. This had led to partial close down of schools and universities and students were inaccessible to me. It took long time before the data was collected. Though these challenges were met along the line during the study, non of these have actually affected the result in any way.

Organization of the Study

The study is organized into five chapters.Following the introduction, the second chapter focused on the review of related literature which was in two

parts, theoretical review and the conceptual framework and the empirical review. Chapter three constututed the research methodology used for the study. It covered study area, research design, population of the study, sample and sampling procedure used, research instrument, data collection procedure and data analysis procedure. The fourth chapter presented the results and discussions of the data analysis. Summary, conclusions and recommendations are presented in chapter five as well as suggestions for further studies.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents the review of related literature to the study.The thematic areas covered in the study include effects of smoking types on the nutritive value of shrimps, chemical change in shrimps during spoilage, relationship between spoilage and temperature, proximate composition of shrimps. Others are acceptability of smoked shrimps relating to wood types, effect of smoking on chemical, physical and nutritional composition of shrimps. The entire literature has been summarized for a quick overview of this chapter.

Conceptual Framework of the Study

The Conceptual Framework for the study consists of five components which mimic the problem under review as presented in Figure 1. Smoking type has been linked with the four other components in the framework. The components in the framework are ‘smoking method’, ‘Nutritional effects’, ‘Attribute of shrimps’, ‘Types of wood’ and ‘Physical/Biological Effect’. The smoking method has a link with the nutritional effects of the shrimps and the attributes of the shrimps as well. The kind of wood used to do the smoking could have an influence on the quality or taste of the shrimp.

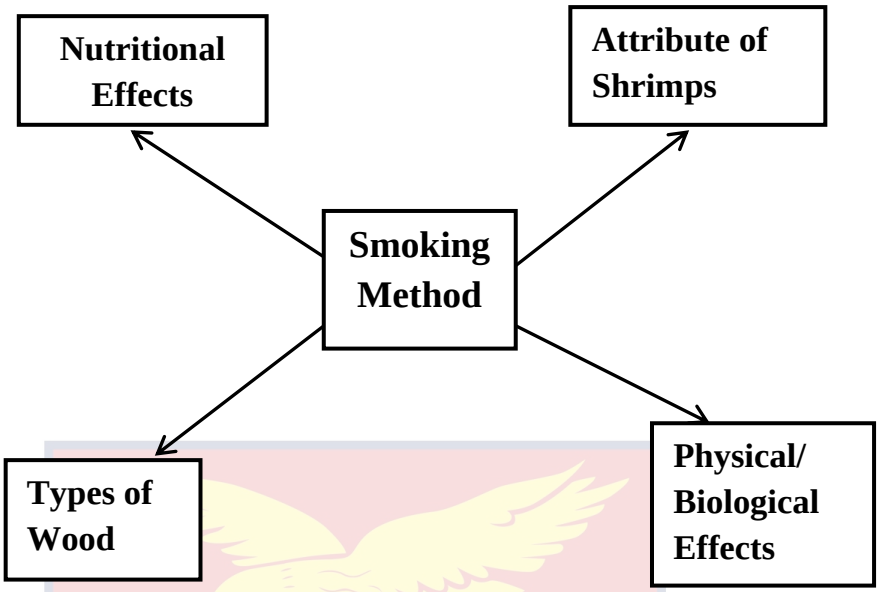

Figure 1: Conceptual framework

Source: Author's Construct, 2020

The 'Physical/Biological Effects' could be influenced on the shrimps that have been smoked. The attribute of shrimps could be influenced by the exposure of the shrimps to the smoking type. The smoking type in this study is the hot smoking. The extent to which the shrimps are exposed to the smoking type could change the original (natural) attribute that is known for *penaeus notialis* which would be used during the study. The nutritional status of *penaeus notialis* as known through literature may be compromised due to the exposure it would have with the smoking types.

In the traditional settings, in smoking fish or shrimps, different wood species are used. Smoking itself is one of the oldest method used in preserving fish, meat and other perishable animal protein base food. It is believed that the smoking types (hot and cold) and wood species used could have some sort of influence on the quality of the shrimps that would be produced.

Shrimps

Shrimps are distinguished by the semi-transparent shell, which is laterally confined. They have two sets of pre-oval extremities; which are against uniform yet sensory in capacities, additionally a platform on which there are teeth both on the ventral and dorsal surfaces. Seafood, which includes shrimps, is dietary staple foods in many countries and aside from their delicacy, they contain amino-acids, peptides, protein and other valuable supplements, for example, calcium and nutrients (Bello, 2013). There is an expansion popular for fish's as they are a generally excellent wellspring of polyunsaturated fatty acids called omega and fatty acids (Yanar & Celik, 2006). The polyunsaturated fatty acid is important to improve human wellbeing and furthermore rich in astaxanthin and vitamin B12 with cancer prevention agent properties.

Shrimps with their characteristic saw wellbeing wellness and culinary credits are progressively the protein selection of individuals around the world. They contain about 18-20 percent protein, 75-80 percent water, low fat 4.5 percent, amino acids and minerals such as selenium, copper, zinc, and calcium in right proportion (Sriket, Benjakul, Visessanguan & Kijroongrojana, 2007; Yanar & Celik, 2006).

The specialists of decay within shrimps are microbes and autolytic catalysts, which work under obliging ideal settings. Microscopic organisms necessitate water and are delicate to warm, salt fixations, and pH while enzymes activities are touchy to temperature changes however can be inactivated by substance irradiation (Venugopal, 2008). Shrimps decay quickly when caught due to their high dampness and protein content except if they are protected by cool stockpiling condition (Kortei, 2015). In Ghana and greatest chunks of the

world, drying and smoking are among the best options of pre-processing seafood. They are the most seasoned methods for food safeguarding and are appropriate to a wide scope of food items including shrimps. Among the few techniques for conservation of fish, smoking is maybe the least difficult strategy as it doesn't need complex gear or profoundly talented specialists (Olayemi, et al., 2011). About 25-30 percent of the world fish catch is consumed in the dried, smoked form or the combination of these processing methods.

Whether prepared or uncooked with sauce, fresh and clean shrimp can still be eaten. Shrimps are highly nutritious, low in fats and calories, and also have a balanced taste from a diet and lifestyle context. (Dayal, Ponniah & Ambasankar, 2011). As a result of these properties, shrimps structure a trademark added substance in salads, pastas, curry, soups and sautéed dishes. Shrimps have moreover been recognized as a rich wellspring of Vitamin B12, selenium, ω-3 significantly unsaturated fats (PUFA) and astaxanthin, an incredible normal cell reinforcement (Venugopal, 2008).

And for its high selenium, docosahexanoic acid and weak fats, shrimp is however advantageous based on its minor anti-inflammatory behavior (cited in Dayal, Ponniah, Khan, Babu, Ambasankar & Vasagam, 2013). Epidemiological investigations uncovered that utilization of fish, incorporating shrimp rich in ω-3 PUFA is related with a decreased danger of coronary heart illnesses (Kris-Etherton, Harris & Appel, 2002; Mozaffarian & Wu, 2011). The US Dietary Guidelines suggest that people at both higher and normal CVD hazard burn-through a normal of at any rate 250 mg/day EPA + DHA (1750 mg/week) (US Department of Agriculture and US Department of Health and Human Services, 2010). Taking in 100 g palatable bit of shrimp every day will

give > 180 mg of EPA + DHA. So as to gauge the affinity of shrimp-eating in diminishing the dangers of coronary illness, the atherogenic and thrombogenic files were determined (Ulbright & Southgate, 1991). Shrimp displayed estimations of 0.36 and 0.29 for atherogenic and thrombogenic files separately, which are lower than other nonvegetarian nourishments, showing its cardio-defensive nature.

There are actually multiple kinds of preservation techniques that can be used for a long time to preserve the quality of food items, either by using traditional or new methods of preservation technology. Several of these techniques of preservation use the addition of food preservatives that can be labeled as chemical and natural preservatives. In Ghana, enhancers such as sugar, food colours, oil, sugar cane, honey etc are added to the food or wood for smoking enhancing the taste, flavor or aroma and color of the smoked food product. Addition of chemical preservatives like sodium propionate enhances shelf life and addition of butyl hydroxyl anisole (BHA) prevent rancidity which is very harmful for the human consumption.

Natural preservatives such as salt, rice bran oil, spices and herbs like turmeric, pepper etc is not harmful for consumption (Khalaf et al., 2008). Dark pepper has notable cell reinforcement and revolutionary rummaging impacts that have been settled and indicated that the take-up of selenium, nutrient B, beta-carotene and curcumin just as different supplements can be enhanced by piperine (Dwivedi et al., 2012). Fishes are very much susceptible to pathogenic bacteria but when antioxidant and anti-bacterial rich spices and herbs are applied they prevent the growth of microbes and thus helped in increasing the shelf life of the product (Gülcin, 2005). Any of these mechanisms have different

effects on the physical and nutritional composition of fish, although they are essential for preservation (Foline et al., 2011).

A key aspect of our global availability of marine food is shellfish (Venugopal & Gopakumar, 2017). In total, shellfish consists of 2 species classes, crustaceans and mollusks (Venugopal & Gopakumar, 2017). Crustaceans are shrimp, lobster, crayfish, crab, and krill invertebrates with segmented bodies, covered by hard shells composed of chitin. Mollusks are soft-body invertebrates, separated into the foot and the visceral portion.

Bivalves, cephalopods and gastropods are subdivided into the foot and the visceral. Mussels, oysters, clams, and scallops are the commercially valuable bivalves, whereas cephalopods comprise squid, cuttlefish, and octopus. The gastropod type includes, among others, abalone, sea snail, cockle, and whelks (Venugopal & Gopakumar, 2017). More than 1000 species of crustaceans, 50000 species of mollusks, besides 13000 species of finfish, are known to populate the marine (Nybakken, 2001).

Shrimps relate to the Decapod crustaceans , a widely complex cluster of species with around 233 relations and 2,725 sorts (De Grave et al., 2009). The class *Penaeus* (Family *Penaeidae*) is in moneytary sense the most imperative set of shrimps containing 27 species (Dall, Hill, Rothlisberg & Staples, 1990; Holthuis, 1980) *Penaeus notialis* (Figure 2) which is one of the most marketed species in West Africa.

The black tiger shrimp (*Penaeus monodon*) (Figure 3), historically extinct from the brackish waters (lakes and lagoons) where shrimp are primarily trapped in Benin, has lately been discovered in the brackish waters of Benin and has also been converted to a commercially available species. The root of this

species' colonization of Benin's brackish waters has not yet been illustrated. However, *P. monodon*, which is indigenous to the Indo-west, has been documented.

Figure 2: Photo of *penaeus notialis*

Source: Abankwah 2020

Figure 3: Photo of *penaeus monodon*

Source: Abankwah 2020

Pacific is now developed due to exits from aquaculture in certain regions, like West Africa (Fuller et., 2014).

Accessible literature points to the fact that the utilization of 'shrimp' and 'prawn' expressions is misleading. It is also used synonymously with shrimp and prawn. *Penaeid* shrimps (shrimps belonging to the *Penaeidae* family) are popularly referred to in America as shrimps and in other English-speaking countries as prawns (Holthuis, 1980). In addition, the hierarchical status of the *Penaeus* group is not unanimous within shrimp taxonomists. The sub-genus identities of *Penaeus* were updated to the level of genus by Pérez-Farfante and Kensley (1997). Flegel (2007), indeed, concluded that revising the taxonomy was not appropriate.

Four sea basins, including the Indo-west Pacific, the eastern Pacific, and the western and eastern Atlantic, are largely populated by *Penaeid* shrimps (Dall et al., 1990; Holthuis, 1980). The shrimp types may display different types of life cycle. Aspect of the development cycle of *Penaeid* shrimps captured from West African coastal brackish waters (lagoons and lakes) has been confirmed to also appear in the Atlantic Ocean. In coastal waters, adults spawn. The post-larvae travel to the brackish waters to mature to the post-juvenile stage following oviposition. Afterwards, for mating activities, the species head to the sea (John & Lawson, 1990; Sankare, N'da & Sylla, 2014).

Two crucial environmental variables influencing the development and existence of shrimps are water salinity and temperature (Dabadé, 2015). For the development of immature shrimp (Penaeus merguiensis), the correct temperature and salinity are 31 ° C and % (Staples & Heales, 1991). At temperatures ranging within 25 and 35 ° C, *Penaeus vannamei* youngsters developed stronger at salinity of around 20 percent (Ponce-Palafox, Martinez-Palacios & Ross, 1997). *Penaeus esculentus* has been observed to have an acceptable temperature and salinity of 30 ° C and 30 % for the development of immature brown tiger shrimps (O'Brien, 1994).

Shrimps: species, habitat and life cycle

The decapod crustaceans, an amazingly varied category of species with about 233 families and 2,725 genera, belong to shrimps (De Grave et al., 2009). Financially, the Penaeus category (Penaeidae family) is by far the most significant group of shrimps (Dall et al . , 1990) featuring 27 varieties (Holthuis, 1980), along with Penaeus notialis (Figure 2), another of West Africa's most commercially produced species. The black tiger shrimp (*Penaeus monodon*),

which in the past was lacking from the brackish waters (lakes and lagoons) where shrimp are primarily collected in Ghana, has recently been discovered in the brackish waters of Ghana and has also become a commercially important species.

The root of this species' colonization of Ghana's brackish waters has still not been illustrated. Even so, it has been confirmed that owing to evasion from aquaculture, P. monodon, which is local to the Indo-west Pacific, is now established in several regions, like West Africa (Fuller et al., 2014).

The utilization of the words "shrimp" and "prawn" is misleading. Sometimes, both concepts are used synonymously. Penaeid shrimps (shrimps belonging to the Penaeidae Family) are commonly referred to in America as shrimps and in other English-speaking countries as prawns (Holthuis, 1980). In addition, the hierarchical status of the Penaeus genus is not unanimous within shrimp taxonomists. The sub-genus titles of Penaeus were updated to the level of genus by Pérez-Farfante and Kensley (1997). Flegel (2007), furthermore, concluded that revising the taxonomy was not appropriate.

Four aquatic basins, including the Indo-west Pacific, the eastern Pacific, and the western and eastern Atlantic, are largely populated by Penaeid shrimps (Dall et al., 1990; Holthuis, 1980). They can depict various life cycle forms. In total, however, minors occupy the brackish waters of estuaries and tidal wetlands, whereas grown ups seek higher salinity and deeper waters inland. Larvae are located off-shore, with an on-shore relocation as they mature, in plankton-rich ground water (Bailey-Brock & Moss, 1992). Portion of the life cycle of Penaeid shrimps captured off West African marine brackish waters (lagoons and lakes) has been confirmed to also happen in the Atlantic Ocean.

The post-larvae move to the brackish waters for development to the post juvenile phase following oviposition. Then, for breeding reasons, the species head to the ocean (John & Lawson, 1990; Sankare et al., 2014).

Two significant abiotic variables that impact the survival and development of shrimps are water salinity and temperature. For immature shrimp development (Penaeus merguiensis), the correct temperature and salinity are 31 ° C and 30 percent (Staples & Heales, 1991). Ponce-Palafox et al . (1997) found that minors of Penaeus vannamei flourished well at salinity of about 20 percent at temperatures ranging from 25 to 35 ° C. Penaeus esculentus has been observed to have an optimal temperature and salinity of 30 ° C and 30 percent for the development of immature brown tiger shrimps (O'Brien, 1994).

Nutritional qualities of Shrimps (*Penaeus Notialis)*

Shrimps are incredibly acceptable wellspring of protein, yet are low in fat and calories consequently, settling on them a solid decision of food. Meat and dairy are additionally acceptable wellsprings of protein however they will in general be exceptionally high in calories and immersed fat (Micha & Mozaffarian, 2010). Shrimps likewise contain a ton of omega-3 unsaturated fats however these unsaturated fats are acceptable and consequently forestalls against coronary illness, circulatory sicknesses and numerous different kinds of diseases. They have a significant level of vitamin B12, zinc, iodine, phosphorus, potassium, selenium and iron yet have more modest amount of magnesium, calcium and sodium. Huge numbers of these nutrients are basic for sound skin, bones and teeth. The short gracefully of creature protein to a level almost beyond the reach of low income earners has thus led to an increase in the demand for prawns (Micha & Mozaffarian, 2010).

Shrimp marketing

Harvested shrimps from sea, fresh water or lagoon have to be marketed except the harvesting is for home consumption. There are markets for shrimps within and outside the country. Belgium, Portugal, Spain , France, and the USA are the key hubs in Europe. The value of semi-processed white prawns is higher[ranging from US$ 3-US$18 / Kg according to sizes 1-7 than the peeled, deveined and decapitated brown shrimps priced between US$ 2 and US$ 3 (Micha & Mozaffarian, 2010). Shrimp captures are normally reasonably safe, but they can include a bit of residue and dirt / sand that is quickly wiped on board the vessel (FAO , 2009).

Of the 36 involved and operating shrimp firms, 14 supplied shrimp to Europe in 1998 and 8028,157 MT of total exports were estimated at US$ 25,865,786.43 (Micha & Mozaffarian, 2010). Extracted shrimps were shipped by only one firm, while the others marketed them organic. Nigeria met the European Union's quality standard and is therefore authorized to export shrimps to Europe (Micha & Mozaffarian, 2010). Since then, shrimp export has become better organized and it is safe to say that no to products from Nigeria as it was in some years in the international market before the introduction of international standards (FAO, 2009).

Consumption pattern of Shellfish

Across the globe, appetite for seafood is growing exponentially, fuelled by increasing demographics and their growing buying power. As per a new analysis, diet, taste, and comfort are the key forces of seafood consumption, while cost, affordability, and quality fears are the key barriers (Christensen, Kane & Farmery, 2017). A total of 146.3 MMT of seafood was utilized as

human food in 2014, resulting in a worldwide per capita consumption of 20.1 kg of seafood, leading to about 20 % of the total annual per capita intake of animal protein. The per capita shellfish utilization of shrimps in 2013 was 4.9 kg, partitioned into 1.8 kg of crustaceans, 0.5 kg of cephalopods and 2.6 kg of different mollusks (FAO, 2016).

A latest review recorded a per capita consumption of 25.8 and 35 kg of seafood in the European Union (EU) as well as Southern Europe (Megapesca, 2017), respectively. The desires of customers in shellfish products include fresh products, consumed whole or minimally processed in different formulations (salted, smoked, coated, canned) and ready-to - eat products (Venugopal, 2006). World market for shellfish as demonstrated by market estimates, which shows that while shellfish accounted for 38 percent of total seafood shipped in 2013 in quantity terms, their share was 63.7 percent in terms of value obtained (FAO, 2016).

Because of its distinctive texture and colour, shrimp, made up of over 300 species, is perhaps the most common shellfish. Medium gray or gray-colored raw shrimp and brilliantly orange-colored boiled shrimp are typically favoured by shoppers (Parisenti, Beir ?? ao, Tramonte, Ourique, Britto & Moreira, 2011). In 2012, per capita shrimp usage in the United States was estimated at around 1.73 kg; nearly 90 percent of the shrimp eaten came from imports (Reed & Royales, 2014).

Bivalves are usually tender and readily absorbed, rendering them desirable to buyers. The soft-shelled and also hard-shelled clams, blue mussel, eastern oyster, and sea scallop are the largest commercial bivalve species. Over the past years, the use of marine mussels has gradually risen (Grienke, Silke &

Tasdemir, 2014). Cephalopods are eaten by Japan, Korea, Argentina, Taiwan, Japan , China and Spain in massive volumes (Vaz-Pires & Barbosa, 2004; Kim & Venkatesan, 2015). Common cuttlefish (*S. officinalis*), European squid (*Loligo vulgaris*), common octopus (*O. vulgaris*), and musky octopus (*Eledone moschata*) comprise prominent cephalopods (Ozogul, Duysak, Ozogul, Ozkutuk & Tureli, 2008; FAO, 2016).

Portunus spp., Charybdis spp., Chionocetes spp., mud crab (*S. serrata*), Dungeness crab (*Metacarcinus magister*) and brown crab (*Cancer pagurus*) are among the widely accepted crabs (Maulvault, Anacleto, Lourenco, Carvallo, Nunes & Marques, 2012; Kim & Venkatesan, 2015). Oysters, mussels, king scallops, lobsters, winkles, whelks, cockles, clams, crab, and others are the species of shellfish eaten in Europe (Ruiz-Capillas & Moral, 2004; Barrento, Marques, Teixeira, Anacleto, Vaz-Pirez & Nunes, 2009a, 2009b; Gu'eguen, Amiard, Arnich, Badot, Claisse, Gu'erin & Vernoux, 2011).

Shrimps smoking

One of the oldest tools for food storage is smoking. Smoking is carried out at a certain temperature and humidity, based on the species and quality of substance desired. Smoke is commonly derived from material from plants (Ahmed et al., 2013). Not only does smoking boost the shelf life, but it also alters the food's look, taste and scent (Beltrin, Peláez & Moral, 1989; Goulas & Kontominas, 2005; Akintola, Brown, Bakare, Osowo & Omolola, 2013). In the smoking industry , various pre-smoking therapies, like salting and drying and/or post-smoking therapies, primarily cooking and marinating, are applied (Ahmed, Zara & Baig, 2013). Smoking is never an efficient form of protection and it is vital to use salt to supplement the bacterial inhibitory effect of smoke by

decreasing the action of water. With increasing salt concentrations, the effects of salt inhibiting microbial growth increase, but for reasons of health and appropriateness, the trend is to manufacture materials with minimal smoke and salt levels (Beltrin et al., 1989).

The mechanism of incomplete combustion of wood causes smoke. Many chemicals such as aldehydes , ketones, alcohols, acids, hydrocarbons, esters, phenols, ethers, etc. are present (Guillen & Errecalde, 2002). By accumulation on the skin and eventual entry into the tissue, these compounds are transmitted to the fish throughout smoking (Goulas & Kontominas, 2005). As a consequence of the cumulative effects of the antimicrobial and antioxidant activities of tobacco, smoking raises the shelf-life of fish.

In most developed nations, conventional fish smoking techniques are also widely practiced. Simple kilns are utilized that use a number of firewood, and it is difficult to regulate the smoking situation (temperature, humidity and smoke) (Oduor-Odote, Shitanda, Obiero & Kituu, 2010). Smoke is introduced to manufacturers and usually low quality goods are processed (Oduor-Odote *et al.*, 2010). Smoking is typically carried out under regulated circumstances in developing nations and therefore can come in two forms, hot and cold smoking. Hot smoking requires cooking and can be called moderate (30-50 ° C) or extreme (50-80 ° C) temperature (Marc Kaaker & Mboofung, 1997), although it is generally achieved at 70-80 ° C temperatures (Erkan, 2012). Cold smoking, on the other hand, is generally observed without cooking at temperatures of about 30 ° C, leading to a lower nutritional loss (Goulas & Kontominas, 2005). Three results are combined through protecting fish by smoking, as per Vijayan (1984).

1. Smoke preservative value: There are a substantial percentage of compounds in smoke released from burning wood, some of which can destroy bacteria, such as phenols.

2. Drying: heat is also developed by the fire that creates the smoke and this will dehydrate the fish.

3. Cooking: when the fish is smoked at an extreme temperatures, the liver is fried and the enzymes are killed and bacteria are destroyed.

In the traditional system of smoking, natural convection smokers are used in which the fish are hung or laid on openwork plate above fire. The warmth from the fire makes a warm section of smoky air rise and disregard the fish. In different kinds, a fire is scorched in a pit over which a table conveying the fish is fabricated. Since the sides of the table are open, a significant extent of the smoke and warmth can escape without disregarding the fish (Oluwatoyin, Williams & Awujola, 2010). In different aspects of the world, a range of versions of smokers have also been produced using locally sourced materials. Vijayan (1984) in (Tropical development and research institute) reported that in spite of the fact that these might be modest to develop, they will in general experience the ill effects of a few, or the entirety of the accompanying disadvantages.

1. They have a high fuel consumption compared to output.

2. They have a low capacity.

3. They require constant attention.

4. They are affected by wind and/or rain.

5. They are difficult to control and the product is not uniform.

6. The materials used in construction are often inflammable.

Wood Smoke Components

A method that has been used from prehistoric days is the immediate introduction of fish to smoke produced by a seething wood fire. Smoke is developed generally utilizing wood that is commonly accessible in a town. In cooking, wood smoke plays many practical functions. It is considered a natural spice and need not be torn down into components in the packaging statement, unless it is added as a gas from seething wood pieces or chips or as fluid smoke. Wood smoke is indeed a colorant where the pigment is created rapidly upon contact within the surface of the food and smoke, or when the smoke and food elements react chemically at the increased temperature utilized during food processing, the color is developed. Since the basis of wood smoke's chemical components is in the wood itself, it will be anticipated that the form of wood and the generation process would influence the nature of the smoke (Chen & Maga, 1993).

There are over 300 compounds in wood smoke, predominantly phenols, carbonyls, acids, furans, alcohols , esters, lactones, and even PAH. The percentage of these components depends upon the sort of wood utilized, the wood humidity, the scale of the wood fibres and the production methods of smoke (Maga, 1987). PAH is renowned for its mutagenic and carcinogenic effects, although much of the taste and preservative attributes are due to phenols.

Phenols do not seem to be a great safety problem, and there is relatively little documentation of phenol mutagenicity present in smoke, such as the Ames assay-based syringol, eugenol, phenol, cresols, vanillin, and guiaicol (Pool & Lin, 1982). In comparison, phenolic content and PAH content have no

association. The desired smoke flavour (derived in part from phenolic compounds) as well as low PAH content are therefore likely. (Pohlmann, Hitzel, Schwagele, Speer & Jira, 2012) So, preferred manufacture processes are those that reduce or eliminate PAH while favoring the phenolic compounds.

Functional properties of smoke components

Flavour

The distinctive wood smoke flavour is commonly known to be attributable to phenolic compounds (Bratzler et al., 1969, Deng, Toledo & Lillard, 1974, Maga, 1987). The concentration of phenols has therefore been used to evaluate the significance of the flavour of smoke in smoked fish or meats (Chan, Toledo & Deng, 1975, Kjallstrand & Petersson, 2001). Flavour, though, is a dynamic feeling conferred by combinations of multiple compounds. The flavour of components of smoke also relies on the concentration. Thus, at large concentration or nice smoky at the desired concentration, the same smoke flavour can evoke sensory responses of burnt, pungent, and cresolic.

Colour

The creation of colour in smoked goods is down to a combination of cold staining and chemical reactions of the Maillard type that are heat-induced. If liquid smoke is utilized, the phenolics and acids add a cold stain. As the food is heated, in a Maillard reaction, the carbonyl compounds combine with the proteins to generate the brown colour. Cold smoking is the concept used at temperatures below the denaturation temperature of the fish muscle (below 40 ° C) when uncooked fish is exposed to comparatively low optical density smoke. As there are not many phenols to create a dye, cold smoked fish may

not change color and the Maillard reaction does not advance far enough to develop the color.

Smoking, on the other hand, prompts expanded gathering of phenolics, the creation of condensed phenolics and extreme browning of Maillard at temperatures of 80 to 90 ° C, so that the substance has a rusty black color with several tiny spots of dull material on a superficial level. A glistening golden honey colour caused by the trapping of phenolics on an oily skin and sufficient Maillard reaction to produce a light brown colour is the perfect smoked fish colour (Deng, Toledo & Lillard, 1974; Chan, Toledo & Deng, 19751). As smoke can be branded as an organic spice, it is a desired ingredient and a roast colour compressor with no smoke flavour at all is one of the applications.

Antimicrobial properties of smoke

Smoke 's antimicrobial effects are well established and represent the vital function of smoke in the protection of food. To bring in the antimicrobial effect, all the components of smoke communicate. Independently, phenolics, acetic acid, and carbonyls possess antimicrobial activity, however their combined action is synergistic. Thus, at a lesser rate of the components than any of the individual components, a blend will be an effective antimicrobial agent.

In consideration of the variations in liquid smoke content, inhibitory function differs with various formulations of smoke. Pathogenic bacteria such as Escherichia coli , Staphylococcus aureus, and Listeria monocytogenes were bactericidal in 0.5 percent of experiments on antimicrobial properties of Charcoal smoke formulations (Wendorff, 1981). For bactericidal activity, some formulations need lesser concentration than others. The elevated bactericidal activity of certain preparations has been speculated to be attributed to the

elevated amounts of polar phenolic compounds in these formulations (Messina, Ahmad, Marcello, Gerba & Paquette, 1988).

Vitamins and Minerals

Vitamins are organic compounds that are important for supporting proper physiological activity in very limited quantities. Human beings need vitamins in daily diets, because the body cannot blend them rapidly enough to meet its every day needs. Vitamin inadequacies therefore can make or intensify persistent medical issue (Andrews, 2014; Higdon, 2003). For a number of purposes, minerals are inorganic compounds needed by the body in limited quantities. This involve bone and teeth formation; as important components of body fluids and tissues; as elements of enzyme processes and for proper functioning of the nerves (British Nutrition Foundation, 2017).

Some minerals, example calcium, phosphate, magnesium , sodium , potassium and chloride, are required in greater quantities than others. Others, such as iron, zinc, iodine, fluoride, selenium and copper, are mandated in smaller amounts and are often called trace minerals. Minor elements are no less basic than different minerals, albeit being needed in smaller quantities. If given in foods but instead as additives, minerals are also consumed more easily by the body. Also, in many others, an eating regimen that is short in one mineral can well be unfortunate, thus the initial phase in fixing this is to evaluate and strengthen the entire diet. Eating a diverse diet will help ensure that most minerals are properly provided to healthier individuals (British Nutrition Foundation, 2017).

Nutrition according to Adigbo and Madah (2010), is the study of nutrients and their relationship with food in living things. As we eat daily,

nutrients in the food become available to the body for it to be used for growth, repair of worn– out tissues, protect the body against diseases, supply energy and regulate all body processes. For as humans, we need to select food that is balanced to be able to gain the needed nutrients as required by the body for proper growth. The science that deciphers the collaboration of supplements and different substances in food according to upkeep, development, propagation, wellbeing, infection of a life form and others is how Wikipedia explains nutrition. It incorporates food admission, ingestion, absorption biosynthesis catabolism and discharge (Whitney & Rolfes, 2013).

The number of different nutrients ingested by individuals differs greatly, and the amount of nutrients found in different foods often varies dramatically. According to Wardlaw and Insel (1996), the sum of every day admission of protein, fat and starch adds up to about 500 g as compared to a typical daily mineral intake of about 20 g with a total of about 300 mg for vitamins.

The National Diet and Nutrition Surveys (NDNS) have shown that certain demographic subgroups have poor intakes of some other nutrients, such as potassium , magnesium, men's zinc , iron, calcium , copper, and iodine for women. Young British grown ups, young women in particular, have notably poor diets which, except if changes are made, are likely to put their future health at risk (British Nutrition Foundation, 2017).

Importance of minerals and nutrients in shrimps

The nutritional composition of shrimps is substantial. According to Dayal et al. (2013), three out of four of the edible portion of shrimps is water. The protein constitutes about 80 % of the total of the remaining component (dry matter). Fresh shrimp 's estimated protein content is 19.4 g/100 g and supplies

87 percent of the entire resources. Such amino acids can not be synthesized by our bodies and they have to be received by diet; they are considered essential amino acids. The Protein Digestibility Corrected Amino Acid (PDCAAS) ranking is dependent on food protein amino acid quality, actual digestibility, and the capacity to deliver essential amino acids as required. The PDCAAS of shrimp is indicating its superior protein quality (Dayal, Ponniah, Khan, Babu, Ambasankar & Vasagam, 2013). The average nutrient analysis done by nutrition data as cited in Daya *et al*. (2013) indicated that shrimps have a lot of benefits to humans. The nutrition composition found is shown in the table below.

Average analysed nutrient profile of 100 g edible shrimp meat

Nutrient mean/std.	Mean and Standard deviation
Protein (g)	19.4 ± 0.56
Lipid (g)	1.15 ± 0.19
Water (g)	76.3 ± 0.57
Energy (kcal)	89.0 ± 1.12
Essential amino acids (mg)	*Essential amino acids (mg)*
Isoleucine	930.7 ± 8.10
Leucine	1463.9 ± 22.30
Lysine	1480.1 ± 27.57
Methionine + cysteine	668.1 ± 16.57
Phenylalanine + tyrosine	1389.2 ± 19.27
Threonine	756.0 ± 8.89
Lipid composition	*Lipid composition*
ΣSFA (mg)	257.5 ± 3.71
ΣMUFA (mg)	163.5 ± 7.90

ΣPUFA (mg)	321.0 ± 5.23
Eicosapentaenoic (mg)	112.0 ± 3.02
Docosahexaenoic (mg)	75.5 ± 1.43
Σn – 3 PUFA (mg)	204.5 ± 2.23
Macro minerals (mg)	
Calcium	107.3 ± 1.96
Magnesium	58.5 ± 1.38
Phosphorus	303.4 ± 3.22
Potassium	259.6 ± 3.25
Micro minerals (µg)	
Copper	918 ± 4.62
Iron	2196.5 ± 16.61
Manganese	50.5 ± 1.64
Selenium	44 ± 1.06

Source: Dayal *et al.* (2013)

Effects of smoking types on the nutritive value of shrimps

Smoking is also another mechanism of preservation techniques that include chemicals such as formaldehydes and phenols that operate as an anti-micro-organism to heat and antimicrobial smoke and support the fish product to have good attractive colour and flavour (Longwe & Fannuel, 2016). Its heating effect, resulting in decreased shrimp water activity, encourages microbial deterioration to be best stored and thus lessens spoilage, improves storage shelf life and thus increases the supply of seafood to consumers. During the smoking phase, the chemical , physical as well as nutritional composition of smoked fish products will be compromised if the duration, temperature and form of wood

are not regulated and chosen in compliance with the requirements. In addition, several diseases can emerge from the carcinogenic impact of woods on customers. Hard texture, colour shift from golden brown to black and depletion of heat-sensitive nutrients are the significant change arising from smoking shrimps (Mojisola, 2014). Burning wood smoke produces a variety of compounds that prevent the growth of bacteria. Heat from the fire allows drying to occur, and the flesh is baked if the temperature is high enough. All of these variables inhibit the growth of bacteria and the activity of enzymes that can induce spoilage (Fellows & Hampton, 1992).

Fish smoking can be classified as hot and cold smoking, based on temperature and customer choice. Depending on the amount of heat produced, the denaturation of protein and amino acids of shrimp would be pursued while smoking, leading to alterations in the physical and chemical characteristics of protein and triggering a decrease in the biological supply of protein (Ihekoronye & Ngoddy, 1985).

Belitz *et al*. (2009), demonstrated that the supply of essential amino acids (methionine, tryptophan, and lysine) could be substantially decreased by excessive heat in most conventional smoking procedures of fish production. Smoking also reduces the more soluble proteins such as myofibrillar and sarcoplasmic component and raises the quantity of insoluble protein, as per Chavan *et al.* (2008). Friedman (1996) also found that the physical depletion of lipids, amino acids, and micronutrients resulted in fats and much more water drops from the fish during the smoking process. At high temperatures, heat smoking often degrades protein and reduces critical amino acid usability.

Furthermore, smoke particles in shrimps are prone to react with nutrients and may bring about the loss of valuable nutrients and antioxidants.

Chemical changes in shrimps during spoilage

Significant food quality qualities entail food spoilage and food safety. Chemical modifications that occur in foods can result in food spoilage and the existence of harmful contaminants (e.g. heavy metals, pesticides) may make food unhealthy. Consequently, the leading cause of spoilage is microorganisms in fishery products (Gram & Dalgaard, 2002) and pathogens may well be present (Huss et al., 2000). The influence of microorganisms on food quality relies upon the properties of the food and its capacity to replicate and thrive under the conditions prevailing in the supply chain. By their initial infection, their handling boundaries and ensuing stockpiling conditions , the makeup of the shrimp microbiota is established (Dabadé, 2015).

Shrimps contain protein, fat, mineral, carbohydrate and high content of free amino acid. Swant (2012) reported that most of the marine fish species contain trimethylamine oxide (TMAO). Specific spoilage bacteria produce ammonia, biogenic amines, organic acids, and sulphur compounds from acids, hypoxanthine from ATP and acetate from lactate. Spoilage organisms produce off odour volatile base compounds from nitrogen compounds. Fat oxidation is a common chemical action in fatty species and contains a high level of polyunsaturated fatty acids (PUFA) and enhances oxidative changes (Swant, 2012).

Chemical spoilage takes place in protein, carbohydrate and fat of the muscle but the most important chemical spoilage processes takes place in the lipid fraction by auto-oxidation process. The very first phase of the algorithm

of oxidation resulted in the formation of hydro-peroxides, which can trigger brown and yellow tissue discolouration but are not tasty. Hydro-peroxide oxidation gives rise to the production of aldehydes and ketones. There is a definite rancid smell to these compounds. Oxidation can be triggered and intensified by stimuli and including fire, light, and many organic and inorganic compounds, such as copper or iron (Huss, 1994).

Relationship between spoilage and temperature

The spoilage rate of shrimp mainly affected by temperature, autolytic reaction, bacterial activities and fat oxidation but temperature has great effect than all other spoilage factors. Higher temperature increases the higher rate of spoilage. Temperature helps to increase the bacterial activities and autolytic reaction that enhance the spoilage. Bacteria grow with certain range of temperature. For this reason psychotropic gram negative, rod-shaped bacteria such as *Pseudomonos, Moraxellu, Acinetobacter, Shewanellu, Fluvobucterium, Vibrionuceue* and *Aeroemonaduceue* grow dominantly of temperate water fish. The bacteria on tropical fish carries higher load of Gram-positive and enteric bacteria due to high temperature (Liston, 1980). At chilling temperature *Shewanella putrefaciens, Photobacterium phosphoreum, Aeromonas spp.* and *Pseudomonas spp*. cause spoilage of seafood. Even so, various species of Vibrionaceae, Enterobacteriaceae and Gram-positive organisms are liable for spoilage at extreme storage temperatures (15º-30°C) (Gram, Trolle & Huss, 1987).

Proximate composition of shrimps

Nutritional and shelf-life experiments of dehydrated smoked and gamma-irradiated shrimp on *Penaeus notialis* from three separate water sources in Ghana confirmed that the proximate composition of sea, lagoon and river shrimp was determined in compliance with normal AOAC protocols following exposure to gamma-ionizing radiation from different radiation sources of Cobalt 60 (SL 515, Hungary). The result exhibited that protein content varied from 27.40 ± 1.30% to 34.35 ± 1.30%, ash 13.80 ± 0.09% to 15.42 ± 0.09%, fat 0.90 ± 0.01% to 1.72 ± 0.01% and moisture 9.36 ± 0.06% to 12.92 ± 0.06% (Akuamoa, Odamtten & Kortei, 2018). In the case of shrimps from the sea, river and lagoon, the protein content ranged between 25.93 ± 1.13% and 34.42 ± 1.13%, ash 11.85 ± 0.08% and 18.25 ± 0.08%, fat 0.76 ± 0.01% and 1.83 ± 0.01% and moisture 9.22 ± 0.05% and 12.72 ± 0.05% (Akuamoa, Odamtten & Kortei, 2018).

A study in China on the effect of hot smoking on shrimps in terms of moisture, protein, lipid and ash was done by comparing the proximate composition of the fresh and the smoked shrimps. The result had revealed that moisture, protein, lipid and ash for the fresh shrimps was 79.95, 14.51, 2.33 and 3.1 while the smoked shrimps were found to have 14.3, 64.38, 9.86 and 12.0 respectively (Hog, Zaher, Islam & Alam, 2006). In exception of the moisture content all the values for the proximate composition being studied had increased per the study results.

Acceptability level of smoked shrimps with a particular wood type

The regional, social and cultural patterns of consumers influence shrimp intake, consumption pace, and tastes (Pieniak, Kołodziejczyk, Kowrygo &

Verbeke, 2011). A variety of sensory factors (taste, scent, texture, etc.) and non-sensory factors (behaviour, beliefs , personal characteristics, perception of danger, etc.) (Honkanen, Verplanken & Olsen, 2006) also impact dietary habits. Shrimp's market potential is largely dependent on the visual attractiveness of their body color; hence, appearance and the subsequent effect on consistency assume a significant part in sustaining a high degree of customer recognition and understanding (Huidobro, Lopez-Caballero & Mendes, 2002).

The interpretation of sea food by customers offers information on personal interactions (e.g., acquaintance with shrimp processing, eating rate) that can affect contextual shrimp awareness (Jodice, Norman, Shenoy & Woosnam, 2006). The understanding of an aqua commodity is influenced by other factors such as seasonal fluctuations, customer revenue, storage, proximity between customers and markets, product characteristics, method of production, amount of bycatch and knowledge. It is not necessary to overemphasize the value of public recognition, allowing different sectors (preparation, sales and economic) to increase customer understanding about the nutritional benefits of *N. hastatus* (Huidobro, Lopez-Caballero & Mendes, 2002).

The study of smoked shrimps in Bangladesh Sundarban mangrove, noted that mangrove wood was cut and dried to reduce the moisture content before using them for the smoking. The result had indicated that smoked shrimp held its general adequacy as long as 60 days of capacity (Hog, Islam, & Kamal, 2008). This has shown how quality the smoked shrimps were for them to last for 60days and still be accepted by consumers. A similar study was done in Nigeria to assess customers' inclination and view of smoke-dried white shrimps

in Igbokoda, a coastal area of Ondo State. Utilizing a 9-point hedonic scale, members of the panel tested the sensory properties of white shrimps. Figures indicates that the organoleptic characteristics of the white shrimps had substantial variations ($p \leq 0.05$) (Omobepade, Adebayo & Amos, 2018).

The samples labelled A3, B2 and B3 had low acceptability while samples A1 and B5 were more accepted than the other samples. The taste of the specimen was the greatest important factor determining the general acceptability of the evaluators, as seen by the significance of their t-Stat. In addition , the analysis found that all sensory characteristics were positively associated with general acceptability (R = 0.71) and 50 percent (R2 = 0.50) based on these sensory characteristics (Omobepade et al. , 2018). Most of the participants claimed they ate white shrimp in dried form with no allergic reactions. Shoppers were extremely pleased in market places with smoked white shrimps; nevertheless, the purported factors for customer satisfaction with shrimps in market outlets were off taste, insufficient taste, unusual appearance and the volume of by-catches.

Effect of smoking on chemical, physical and nutritional composition of shrimps

In assessing the effect of smoking on shrimps' nutrients, the result indicated that shrimps subjected to hot smoking at 71 °C and suns drying at ambient temperature of 31 °C treatments were compared to fresh samples (Akintola, 2015). The dry weight basis of the proximate composition revealed that the smoking food was higher in protein and carbohydrates ($P<0.05$) whereas fat was maximum in sundried foods ($P<0.05$). The monounsaturated fatty acids (MUFAs) were highest ranging from 35.87 to 40.35 % in all

products. Oleicacid (18:1) had highest value of 24.26% in the smoked. The study further indicated that smoking method as compared to sun drying with respect to quality and nutrition, smoked samples however, offered the best benefits (Akintola, 2015). Sun drying and smoking happened to be the old method of preserving fresh shrimps and even other proteins from either the river or sea. The study of Akintola (2015) had indicated why smoking should be chosen over the sun drying method of shrimps' preservation.

In Bangladesh, a study carried out found effect on the actual properties, proximate structure, mineral substance and amino corrosive worth. The outcome had demonstrated that the nature of conventional smoked item is very acceptable (Hog, Islam, & Kamal, 2008). According to Akintola (2015), effect of smoking shrimps subjected to hot smoking at 71 °C, revealed that smoked product were highest in protein and carbohydrate ($P<0.05$) while fat was raised in sundried products ($P<0.05$). Of both products, monounsaturated fatty acids (MUFAs) were the largest, spanning from 35.87 to 40.35%. In the smoking shrimps, oleic acid (18:1) had a peak value of 24.26 %.

A study done to see the influence of exposure to gamma ionization to shrimps has shown that the protein content ranged from 27.40 ± 1.30% to 34.35 ± 1.30%, ash 13.80 ± 0.09% to 15.42 ± 0.09%, fat 0.90±0.01% to 1.72±0.01% and moisture 9.36±0.06% to 12.92±0.06% (Akuamoa, Odamtten & Kortei, 2018). The result clearly shows that the protein and other attributes of shrimps vary. The variation of the attributes of the shrimps with respect to the amount of exposure to gamma ray could change depending on the amount of the exposure to the ray.

The study further indicated that from the sea, river and lagoon, protein content ranged between 25.93±1.13% and 34.42±1.13%, ash 11.85 ± 0.08% and 18.25 ± 0.08%, fat 0.76 ± 0.01% and 1.83 ± 0.01% and moisture 9.22 ± 0.05% and 12.72 ± 0.05% (Akuamoa, Odamtten & Kortei, 2018). Mineral and amino acid content of the smoked product is satisfactory. Mineral content of smoked shrimp is much higher than smoked *Barbus spp.* (Qudrat-I-khuda, De, Khan & Debnath, 1962) and comparable to local sun dried shrimp (Institute of Nutrition & Food Science, 1977). A smoking temperature of about 150^0C will affect the availability of lysine, one of the essential amino acids found in fish protein (Virulhakul, 1995) but this is much higher than the temperature used to smoke prawns.

Smoking as form of preservation

In most developed nations, smoking is a common conventional form of preserving fish. Smoking integrates the impact of the killing of bacteria by smoking chemicals, such as phenols, with the frying of fish in order to achieve elevated temperatures. The drying as well as cooking results have been due to smoked fish products having a long life span (Adeyeye & Oyewole, 2016). Smoke is created as a result of incomplete combustion when wood and sawdust are burned.

The smoke emitted depends upon the amount of air available and the wood or sawdust content. Soft woods contain a great deal of smoke, which can contribute to the finished foods being blackened. Wood smoke is a blend of volatile chemicals, vapour, and toxic compounds from chemical materials. While smoking, the toxic compounds are ingested and develop the distinctive scent on the wet skin of fish (FAO / UN, 1969).

Adequately smoked fish items are dark brown in colour and are often almost fully cured, as is often seen on fish markets. This means that the life span is extended and the commodities are in reasonably good shape for the customer (FAO, 1971a).

Pre-drying or salting prior to actually smoking; cold-smoking involving the utilization of limited fuel-wood that generates low heat and does not last long for the items obtained; and hot-smoking involving the use of of even more heat by burning huge amounts of fuel-wood (Clucas, 1982). Hot-smoking goods are more delightful (Osuji, 1976) and also have higher shelf-lives (Maddison, Machell & Adams, 1993). By curing, frying and discharging natural wood-smoke chemicals such as tars, phenols and aldehydes, smoking protects fish, both of which have strong bactericidal activity and prohibit other micro-organisms from developing on fish surfaces (Garrow & James, 1994). The flavour of smoking rests in the amount of smoke in which the skin is covered (Anazonwu-Bello, 1976).

Wood species used for smoking and effect on nutritional properties of shrimps

A research was carried out on the impact of the fuel and kiln form on the amounts of polycyclic aromatic hydrocarbon (PAH) in smoked shrimp, a Beninese food condiment. The findings revealed that only shrimp smoked in a chorkor kiln using acacia charcoal had PAH amounts (benzo[a]pyrene = 5 µg kg-1 and benzo[a]pyrene, chrysene, benzo[a]anthracene and benzo[b]fluoranthene = 28 µg kg-1) in conjunction with the European standard of 5 and 30 µg kg-1, collectively, and satisfactory physicochemical

characteristics for good storage (moisture content = 11.9 % ± 1.5 %; water activity = 0.46 ± 0.03)

According to the study of Kpoclou *et al.* (2014), two types of fuel obtained from two kinds of tree were used for the smoking of the shrimps. Charcoal and wood from *A. auriculiformis* (8% and 23% moisture content respectively) and *M. indica* (9% and 10% moisture, respectively). *A. auriculiformis* wood is the most used fuel in cottage industry smoking units in Benin (45% of processors) (Kpoclou et al., 2014); while *M. indica* wood was chosen because it is less rich in lignin than all the other woods used as fuel in shrimp smoking, according to guidelines from CAC (2009).

Wood species for smoking and preference of shrimps

The flavour of smoking rests in the amount of smoke in which the skin is covered (Anazonwu-Bello, 1976). The colour is determined by smoke, which is one of the characteristics that draw buyers. The colour depends primarily on the technique as well as the sort of fuel wood utilized to smoke the cod. It varies in colour from black, medium brown, golden brown or light brown to dirty white. The colour choice of smoked fish for customers differs from location to location. For example, buyers in Southern Ghana desire golden brown-colored smoked fish for urgent use, but dark brown for preservation or transport, according to Obodai, Muhammad, Obodai and Opoku (2009) (per. Com. with Maku Adinortey, Fishmongers' Association, Duakor, Cape Coast). Buyers, however, exhibit differing standards of choice for dark and light brown colours at Bontanga in the Northern Region of Ghana. Specific fuel wood varieties are used by fishmongers to achieve the desired colours (Obodai et al, 2009). There

are concerns that unhealthy colours (sooty or white) are imparted by some kinds of fuel wood (Obodai et al., 2009).

The research analyzed the appetite and understanding of shoppers for smoke-dried white shrimp in Igbokoda, a coastal region of Ondo Province, Nigeria. The community was picked purposely because the town in Ondo State , Nigeria, is a large cluster of indigenous people from coastal communities in Ilaje and Ese-Odo LGAs. For the research, forty shrimp shoppers (20 males and 20 females) were randomly chosen. Data showed that perhaps the organoleptic characteristics of the white shrimps had substantial variations ($p \leq 0.05$) (Omobepade, Adebayo & Amos, 2018).

According to the study (Omobepade, et al., 2018), there was poor acceptability of samples A3, B2 and B3, whereas samples A1 and B5 were much more acknowledged than the other samples. As demonstrated by the significance of its t-Stat, the taste of the samples was the greatest significant factor affecting general acceptability between evaluators (Omobepade, Adebayo & Amos, 2018). The result further revealed that all the sensory attributes were positively correlated (R = 0.71) with general acceptability and 50% (R2 = 0.50) dependent on these sensory attributes. Most of the participants claimed they ate white shrimp in dried form with no allergic reactions. Shoppers were extremely pleased in market places with smoked white shrimps; nevertheless, the purported variables that dictated customer satisfaction with shrimps in market outlets were off flavor, insufficient taste, strange appearance and the volume of by-catches (Omobepade et al., 2018).

Summary

There are a lot of shrimp species that live in fresh water, lagoons, sea or lake. Shrimps belong to the decapod crustacean family called *penaeidae*. The common varieties of shrimps are *penaeus monodon* and *penaeus notalis*. *Penaeus notalis* is a good source of protein and have high calories and saturated fats. Omega -3 and fatty acids which are good in helping heart related diseases. The high level of vitamin B_{12}, zinc, iodine, phosphorous, potassium, selenium, iron among others make the consumption of shrimps to become more popular.

Smoke from the consuming wood contains various mixes of compounds which limits the growth of bacteria in shrimps. The heat from the fire causes drying of the shrimps and makes the shrimps cooked. Seafood is highly vulnerable to invasion by opportunistic and pathogenic microorganisms. Though smoked shrimps last for a while during its shelf-life, when the shrimps are getting spoilt, the bacteria responsible produces enzymns like ammonia, biogenic amines, organic acids, sulphur compounds among others become harmful to human consumption. Temperature of spoilt was found in literature to be one of the most factors that activate bacteria growth on shrimps.

Literature had indicated that proximate composition of shrimps varies after they have been smoked. The moisture, protein, lipid and ash of the fresh and smoked shrimps were compared and the result was significant. Acceptability of smoked shrimps depends on the colour, flavor and taste of the shrimps.

CHAPTER THREE

RESEARCH METHODS

The chapter looked at the research design, study location, population, sample and sampling procedure, instruments used in collecting data and tools used in the analysis of the data.

Research Design

The experimental research design was adopted by the researcher. Experimental method is a scientific and systematic approach to research in which "experiments are carried out to explore the relationship between variables" (Nunan, 1992 p. 12). Each research carried out using a scientific approach is experimental research, where a set of indicators are left constant while the other set of parameters are evaluated as the focus of the experiment. Once the results are analyzed, they can be applied to various other similar aspects and can be used in association with other research methods (Nunan, 1992).

Study Area

The study was conducted in Kumasi in the Ashanti Region of Ghana. The Kumasi Metropolis is the most populous area of the Ashanti Region of Ghana. The Metropolis accounts for nearly one-third of the region's population. It is located at a distance of about 270 Km from Ghana's capital city, Accra. Currently, the population of Kumasi is estimated at 3.348 million (KMA, 2020). The Ashanti Region is located centrally in the middle belt of Ghana. The region is bordered by the Brong and Ahafo Regions to the north, Eastern Region to the east, Central Region to the south and the Western region to the South west.

Kumasi is a city where a lot of marketing activities in various forms are done by people from different walks of life.

Population

A population is the general group from which the researcher desires to obtain data from to study (Frankel & Wallen, 2006). The focus audience that a study is involved in gathering knowledge and making assumptions, as per Amedahe (2004), is what has been regarded as the population. This is a gathering of persons who may have one or more attributes in general that are of concern to the investigator.

The total population was students in the Catering and Hospitality Department at the Kumasi Technical University. The population comprised first year, second year and the third years that were pursuing their full-time and Part-time programmes. They were estimated to be about 400.

The target population for the study was the second year students on the Full-time Programme in the Catering and Hospitality Department in Kumasi Technical University. The target population was 100 students which includes males and females (Kumasi Technical University, 2020). The students were chosen because they were into food production and services. It is hoped that they hd much knowledge in food safety and preservation hence their choice.

Sampling Procedure

The total population of all students in the Catering and Hospitality Department in Kumasi Technical University was about 400 which comprised first year, second year and the third year pursuing full-time and part-time programmes. The target population for the study was 100 students on Full time programme. In sampling the 100 participants, Krejcie and Morgan's (1970)

have suggested a table to be used for sampling. The sample size of the study was 80 students in accordance with Krejcie and Morgan's (1970) table of sample determination. Also the Affective or Hedonic test method uses 75-150 people or participants (Martinsdottir, Sveinsdottir, Luten, Schelvis-Smit & Hyldig, 2001) so 88 students fall within the range. Random sampling was used to sample respondents from second year. The target population (100) was used to divide the sample size (100/88) = 1.3 and the result rounded down to one (1). One participant was therefore selected from the sample frame (Class attendance register) one after the other until the 88th sample was selected.

Data Collection Instrument

The instrument for sensory data collection was a questionnaire. The questionnaire used five-point Hedonic Scale to determine the acceptability level of smoked shrimps. The shrimp samples were coded to hide their true identity from the panelists. The hiding of the sample identity was to prevent bias assessment or evaluation of the shrimps. The shrimps for analysis were in two forms which were un-powdered and powdered shrimps. The samples were coded using the scientific name for the fuel wood used for smoking the shrimps for easy identification. For instance, sample coded 'USTI' and 'USPM' stand for 'Un-powdered shrimp smoked with *Terminalia ivorensis and Petersianthus macrocarpus* respectively. Powdered smoked shrimps were coded as 'PSTI', 'PSPM' stands for 'powdered shrimps smoked with *Terminalia ivorensis' and 'Powdered smoked Petersianthus macrocarpus* respectively.

Laboratory equipment used to conduct the samples, analysis at the laboratory includes, weighing balance, thermometer, test tube, spatula, mortar and pestle, etc. Tools and equipment for smoking of shrimps include kiln or

oven, wire mesh, perforated metal drum, rectangular wood frame, etc. Reagents such as hydrogen peroxide, selenium powder, Lithium Sulphate, sulphuric acid and HCl were used for the laboratory data analysis.

Data Collection Procedure

Fresh shrimps (*Penaeus notialis*) were bought and transported on ice in a cold box from Elmina landing beach in Cape Coast. The reason for transporting the shrimps on ice-block is to prevent them from spoiling. As quickly as the fish or shrimp dies, spoilage starts, so it can start even before the sailors raise the fishing equipment out of the water. For example, as per some reports by the Bay of Bengal Programme (BOBP) (FAO, 1991), the traditional practice in several nations of keeping gill nets to "soak" for extended periods creates a significant proportion of losses, over 25 percent. The spoilage processes of shrimps are continuous and cannot be reversed; no amount of icing will convert poor-quality shrimp back into a good-quality product. Therefore the needed measures like adding ice-block immediately it was caught by the fishermen on sea before landing and also regular icing was adhere to during travelling with the shrimps to Kumasi for processing. There are different species of shrimps in the sea so the shrimps that were bought have been sampled carefully and sorted to ensure a homogenous population of *Penaeus notialis*. The shrimps were washed in consumable water to decrease the degree of microbial burdens going with them from their muddy habitat in the sea and physical contamination with the shrimps.

The shrimps were drained in perforated basket and dried at room temperature. It was weighed using weighing scale to know the exact quantity being used. Ten kilograms of the cleaned shrimps was weighed into three to be

used for the different kinds of wood that have been selected for the various smoking methods.

The smoking treatment was hot smoke drying. The shrimps were arranged on wire mesh supported by a rectangular frame work of wood for the smoking. A temperature of 160°F (71°C) was ensured during the smoking process using mercury-in-glass thermometer for the measurement. The shrimps were ensured to be well smoked by regulating the fire and the shrimps turned regularly until uniform brownish colour was observed. An average temperature was recorded during the smoking process.

The smoked shrimps were placed in plastic baskets and labelled according to the type of wood. The smoked shrimps were allowed to cool in a room temperature for two days in an airy and dust free environment. The plastic baskets were covered to avoid contamination from the smoked shrimps. A sample of 5Kg was taken from each group of smoked shrimps according to the wood used for the smoking process. The whole shrimps were pounded in mortar with pestle untill a smooth texture was achieved. The powdered shrimps were sent to the chemical laboratory in the University of Cape Coast for biochemical analysis. The un-powdered shrimps and the powdered shrimps were given to participants from the Department of Catering and Hospitality in Kumasi Technical University for the the sensory evaluation. The sensory evaluation was done by the participants following a questionnaire (See Appendix A). Sensory evaluation was conducted on whole and podwered shrimp to establish consumer preference with the scales; aroma/flavor, appearance, colour, taste, texture and overall acceptability using five point hedonic scales (Martinsdottir, Sveinsdottir, Luten, Schelvis-Smit & Hyldig, 2001).

Fuel for smoking Penaeus Notialis in Cylindrical metal oven

The wood fuel used for smoking the shrimp variety for the study were *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia) and *Albizia zygia* (Okro). Despite the fact that there are different wood used by the the study had limited the type of wood that were used to do the smoking. Emire is a large deciduous forest tree ranging in height from 15 to 46 metres. The hole is very straight with small buttresses for up to 30 metres with a diameter from 2 - 4.75 metres in diameter. One of the first woods of West Africa, it is broadly reaped from the wild and has been brought into numerous other tropical nations as a promising lumber plantation varieties. It is likewise developed as a shade tree in cacao farms in Ghana.

The bark of Emire is also gathered from the wild for nearby use as a medication and dyestuff. The wood is used as fuel wood and is highly valued for making charcoal (Useful Tropical Plants, 2018). Esia is a perennial tree with a well-developed crown; this could grow to a height of 50 meters. In diameter, the straight, cylindrical bole may be more than 100 cm. For traditional use as a medication and wood supply, the tree is picked from the wild-the wood is often sold and can be used for fuelwood and charcoal. The heartwood is reddish brown, darkening upon exposure and often speckled with darker streaks. The green wood creates an incredibly disagreeable smell when cut, however this vanishes after drying. The wood contains 39.5–40.5% cellulose, 29–30% lignin, 14.5–15.5% pentosan, 0.4–0.6% ash and little silica. The solubility is 6.2–9.6% in alcohol-benzene, 2.1–3.3% in hot water and 18.3% in a 1% Sodium Hydroxide (NaOH) solution (Useful Tropical Plants, 2018).

Okro, with a spreading crown and a beautiful structural shape, is a fast-growing, medium-sized deciduous tree. It can vary in height around 9 to 30 meters and can create a clear bole up to 15 meters tall while rising in the trees. It is being used traditionally in herbal medicine, as a multifunctional tree, and is also often used for food and other products. It is also important in the world timber market as an antique shade tree, roadside tree and firebreak, even though it is regarded to be a relatively lower-used plant. The three wood types used for smoking the shrimps are shown in plate 1 - 3 with their names.

Plate 1: *Terminalia ivorensis (Emire)*

Source: Abankwah 2020

Plate 2: *Petersianthus macrocarpus (Esia)*

Source: Abankwah 2020

Plate 3: *Albizia zygia* (Okro)

Source: Abankwah 2020

Plate 4: *Smoking equipment used for the Smoking*

Source: Abankwah 2020

Cylindrical metal oven was the smoking equipment used for the smoking. Typically, the oven is formed by joining two open 44-gallon steel oil drums together and carving a stokehole at the middle. The typical metal oven diameter is approximately 115 cm, with a height of approximately 90 cm and a stokehole diameter of approximately 40 x 40 cm. Iron rods are mounted about 60 cm above the drum base to act as protection for the fish beds. This oven has been used in African nations. It is light and compact, but vulnerable to corrosion and rust. As with the cylindrical mud oven, it operates from the very same drawbacks. Moreover, as it is made of silicon, it emits substantial heat to the processor's annoyance during the smoking process (Adelowo, Okomoda, Mdailbli & Eyo, 1997; Nti, Plahar & Larweh, 2002). The metal oven was classified as plate 4 with the form of wood used for smoking.

Plate 4: *Terminalia ivorensis* (Emire) *Petersianthus macrocarpus* (Esia) *Albizia zygia* (Okro)

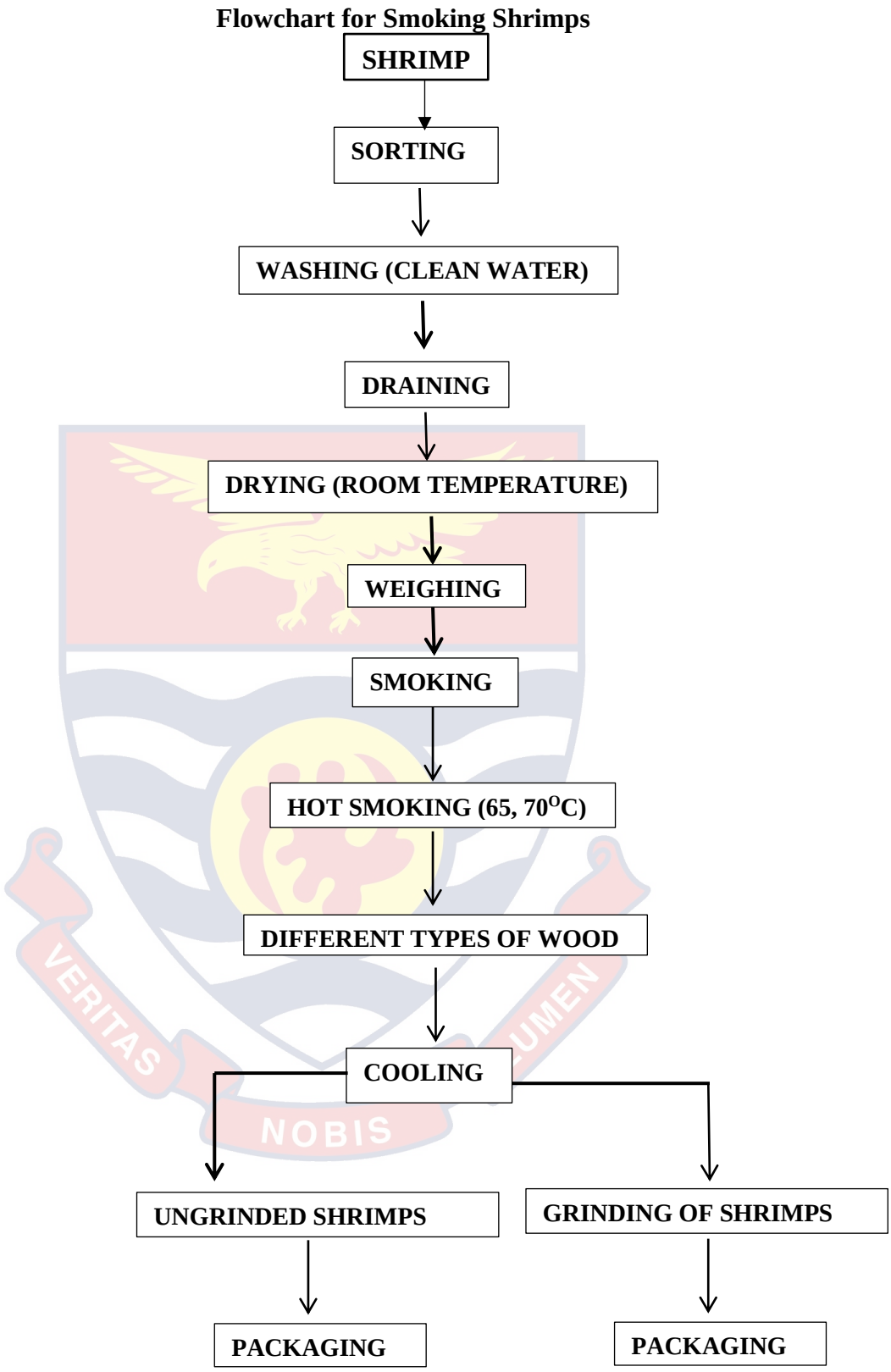

Figure 4: Flow chart for smoking

Source: Author's Construct, 2019

Pre-Testing of Instrument

The pre-testing of the questionnaire was done to ensure its reliability to collect a reliable data for the study. The pre-testing was done in the Department of Vocational and Technical Education (VOTEC), Wesley College of Education Kumasi. Twenty students were conveniently sampled to respond to the instrument using samples from the smoked shrimps with the various wood types. The respondents were given explanation on how to use the instrument. The result was used to re-structure the questionnaire to eliminate ambiguity.

Sensory evaluation of Shrimps

The smoked shrimps were divided into two and one portion grinded into shrimp powder and the other portion whole. The panelists were assembled in a large room in Kumasi Technical University. They were given direction as to what to do during the process. Sensory analysis is a research discipline required to fully measure, examine, and classify responses to food and material characteristics as experienced by the senses such as sight, scent, taste, touch , and hearing (Stone & Sidel, 1993). The characteristics of food are perceived by the five senses; sight, smell, taste, sound and touch. Sensory evaluation is important in the food industry.

According to Institute of Food Technologists (IFT), (1981) sensory evaluation is useful in the development of a new product, product matching, product upgrading, process modification, cost cutback, selection of another cause of supply, quality control, stockpiling soundness, item evaluating and rating, shopper acknowledgment as well as suppositions, purchaser inclination, specialist determination and preparing.

There are many types of sensory evaluation methods, but the most commonly used methods are the difference tests, descriptive analysis and consumer acceptance tests (Lawless & Heymann, 1998). Difference tests estimate the extent of sensory differences between samples. In order to determine the level of customers approval for a product , market acceptance, desire, and hedonic (degree of liking) measures are utilized. Product acceptance can be determined using the category scales, ranking tests and the paired-comparison test.

According to Spence (2015) food colour plays an essential function in driving liking and the consumer acceptability of a variety of food products. However, Singh-Ackbarali and Maharaj (2014) also highlighted that shading and appearance are files of the inalienable great nature of foods related with worthiness. Sample photos indicating the process have been presented in plates 5 – 10.

Plate 5: *Powdered and un-powdered shrimps*

Source: Abankwah 2020

Plate 6 : *Powdered, un-powdered shrimps, bowls and disposable plates*

Source: Abankwah 2020

Plate 7 : *USTI, USPM and USAZ, shrimps and disposable plates*

Source: Abankwah 2020

Plate 8 : *Education on how to do sensory evaluation*

Source: Abankwah 2020

Plate 9 : *Panelist do sensory evaluation*

Source: Abankwah 2020

Plate 10 : *Panelist with three different samples*

Source: Abankwah 2020

Ethical Consideration

The Institutional Review Board (IRB) at the University of Cape Coast granted ethical consent to request authorization from the different institutions and laboratories where the experiments were performed. The form laid out the purpose of this research, the need for individual involvement, anonymity and secrecy of the answers of the respondent. The data provided by the participants were not altered to achieve any objective since this negates the aim and purpose of research.

Determination of Proximate Analysis

Moisture content determination

Porcelain crucibles were washed dried and gauged. 10 grammes of fresh samples were placed into the pot and gauged. The crucibles containing the fresh samples were placed in the oven at a temperature of 105ºc for 48 hours. Toward the finish of the period, the crucibles were brought out, cooled in a dessicator and gauged. The dampness content was then determined as a level of dampness lost by the sample.

Dry matter determination

After the moisture lost calculation, the dry sample weight was noted and expressed as a percentage of the fresh weight.

Ash determination

The dried samples in the crucibles were relocated to the burnt hot plate for an amount of time for the smoke escape. Then, the burned samples were shifted to a drying oven and sparked for 8 hours at 550ºc. In dessicators, the crucibles housing the samples were then chilled and measured. Then the ash ratio was estimated as:

$$\% \text{ ASH} = \frac{\text{weight of ash}}{\text{Original weight of sample}} \times 100$$

Crude protein determination

By quantifying 0.2 g of the milled sample into a labeled kjedahl digestion flask, the protein was determined. A digestion concentrate of four and a half milliliters was incorporated and the sample was digested for two hours at 360ºc. The digest was left to settle and was blended with purified water up to 100ml. After applying ten milliliters of alkali concentrate, twenty milliliters of the digester was straightforwardly distilled using five milliliters of boric acid as

the predictor. 50ml of the distillate was extracted and titrated to the pink end state towards 0,00712 M HCl. The protein ratio was computed using the formula:

$$\%N = \frac{\text{Sample Titre} - \text{Blank Titre) x Molarity of Hcl X 14.007}}{\text{Sample weight (mg)}} \times 100$$

%Protein = %N x 6.25

Fat/Oil Determination

Twenty grammes of the milled sample was measured into a 50 x10mm soxhlet withdrawal thimble. This was moved into a soxhlet extractor of 50ml size. A dried clean 250ml round bottom flask was weighted. About 150ml of petroleum spirit of boiling point 40-60ºC was added and connected to the soxhlet extractor; and extraction commenced for five to six hours, after the four hours the flask was removed, cooled in a dessicator and weighed. The percentage fat/oil was calculated as followed.

$$\text{CRUDE FAT (\%)} = \frac{\text{W (g)}}{\text{Sample Wt (g)}} \times 100$$

W= Weight of Oil

Fiber determination

One gram of the sample was weighed into a boiling flask, hundred mililiters of 1.25% sulphuric acid solution was added and boiled for thirty minutes. Filtration was conducted in a sintered glass crucible with numbers. The solvent was moved to the boiling flask and 1.25% sodium hydroxide solution was added to 100ml and boiled for 30 minutes. After heating, the filtration progressed and also the excess was cleaned with water and methanol. The crucible was dehydrated overnight in an oven at105ºc and measured. The weighed crucible was placed in a furnace at 500ºc for four hours. The crucible was slowly cooled and weighed.

% Crude fibre = $\frac{weight\ loss\ through\ ashing}{original\ weight\ of\ sample} \times 100$

Carbohydrate Determination

Some of the milled sample was weighed into a fifty mililiters conical flask and thirty mililiters of distilled water added. The content was allowed to simmer gently on a hot plate for two hours. It was toppled periodically to thirty mililiters and allow to cool after the two hours. The solution was filtered into a fivety mililiters conical flask and topped to volume. The extract was kept for colour development. Two mililitres of glucose standard solution and the extract were pipette into a set of boiling tubes, ten mililiters of anthrone solution was rapidly added to the boiling tubes mixed thoroughly and cooled under running tap water or ice bath. The tubes were placed in a beaker containing boiling water in a dark fume cupboard for ten minutes. The tubes were allowed to cool in cooled water in the dark. The optical density of the standards and the sample solution was measured at six hundred and twenty-five minutes using the spectrophotometer. A calibration graph was prepared from the standards and used to obtain miligram glucose in the sample aliquot.

% carbohydrate = $\frac{C(mg)X\ extract\ volume}{10\ X\ aliquot\ X\ sample\ wt(g)}$

Where C(mg) = carbohydrate concentration from the graph (AOAC, 2005).

Preparation of sample solution to Determine N, K, Na, Ca, Mg, P, Zn, Cu and Fe

An oxidation process that is required for the degradation of organic matter by acid oxidation before a full elemental analysis can be carried out requires the processing of sample solutions appropriate for elemental analysis.

Sulphuric acid-hydrogen peroxide digestion

The digestion mixture comprises three hundred and fifty mililiters of hydrogen peroxide, 0.42grams of selenium powder, 14grams Lithium Sulphate and four hundred and twenty mililiters sulphuric acid. The digestion procedure as outlined in Stewarte et al 1974 states that between 0.1000g to 0.2000g of the oven-dried ground sample was weighed into a hundred mililiter Kjeldahl flask and four.four liters of the mixed digestion reagent was added and the samples digested at 360^{o}C for two hours.

Blank digestion (digestion without the need for a sample of the digestion mixture) was rolled out in the same manner. The digests were quantitatively transferred to hundred liters of volumetric flasks following digestion and developed up to volume.

Colorimetric determination of phosphorus using the ascorbic acid method

The process involves the preparation of regular formulations for the colour shaping solvent and phosphorus. The solvent producing the colour consists of solvents A and B. Reagent A is made up of twelve grams ammonium molybdate in twenty liters distilled water 0.2908g of potassium antimony tartarate in hundred mililiter distilled water and one liter of 2.5M H_2SO_4. The three solutions were mixed together in a two liters volumetric flask and made up to volume with distilled water.

Reagent B was formulated for each and every two hundred activists with reagent A by disintegrating 1.56 g of ascorbic acid. A stock solution of 100µgP / mL solution was determined from which a range of Phosphorus working conditions with compositions of 0, 0.1, 0.2 , 0.4 , 0.6, 0.8 and 1.0µgP / mL were acquired from a 5µgP / mL solution in 25mL volumetric flasks. The 2mL aliquot

was pipetted into 25mL volumetric flasks of the digested samples. In order to give the samples and the benchmarks identical context solution, 2 mL aliquot of the blank digest was pipetted into each of the workplace conditions. Along with the samples during which 4 mL of reagent B was applied and their quantities made up to 25mL with filtered water and fully combined, 10mL of filtered water was added to the specifications. After the absorption spectra of the standards and samples were measured using a spectrophotometer at a wavelength of 882 nm, the flasks were permitted to pose for color creation for 15 minutes. A calibration graph utilizing their proportions and absorbances was drawn. From the standard curve, the amounts of the sample solutions were extrapolated.

Calculation

If C = μgP/mL obtained from the graph,

then μgP/g (sample) = C x Dilution Factor/weight of sample (IITA, 1985).

Determination of Potassium and Sodium

Potassium and sodium in the digested samples were determined using a flame phometer. In the determination the following working standards of both K and Na were prepared: 0, 2,4,6,8 and 10 μg/mL. The working standards as well as the sample solutions were aspirated individually into the flame photometer and their emissions (readings) recorded. A calibration curve was plotted using the concentrations and emissions of the working standards. The concentrations of the sample solutions were extrapolated from the standard curve using their emissions.

Calculation

$$\mu\text{gK/g} = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

μgNa/g = $\frac{\text{C x solution volume}}{\text{Sample weight}}$ (Stewarte *et. al* 1974)

Determination of Calcium and Magnesium by Edta Titration

The method involves chelation of the cations with ethylene diaminetetra-acetic acid (EDTA). The procedure involved the determination of calcium and magnesium together and the determination calcium alone and magnesium found by difference. By inserting an aliquot of 10mL of the sample solution in a 250mL conical flask, calcium and magnesium together is measured and the solution was diluted to 150mL of purified water with 15mL of buffer solution and 1mL of potassium cynacid, hydroxylamine hydrochloride, potassium ferrocyanide and triethanolamine (TEA) each. Five drops of erichrome black T (EBT) were incorporated and 0.005 M EDTA was titrated to the solution. By pipetting 10mL of the sample solution into a 250-conical flask, calcium was measured and dissolved with purified water to 150mL. Five drops of calcon predictor were applied to 1mL each of potassium cyanide, hydroxyl-amine-hydrochloride potassium ferro-cyanide and TEA, and 0.005 M was titrated to the mixture.

Calculations

$$\% \text{ Ca} = \frac{0.005\ X 40.08\ X\ T}{sample\ wt.}$$

$$\% \text{ Mg} = \frac{0.005\ X 24.31\ X\ T}{sample\ wt.}$$

Where T = titre value

(Page *et al*., 1992)

Data Analysis Procedure

The data collected with respect to sensory evaluation was screened to ensure all the needed spaces were completed. The data from the chemical

laboratory and the sensory evaluation were entered into computer software called IBM-SPSS version 25 for Windows. Sensory evaluation was conducted on the shrimp powder for difference in consumer preference of aroma, appearance, colour, taste, texture and overall acceptability using five point hedonic scales. One way Analysis of variance (ANOVA) was used to check for the significant differences among the types of wood used in smoking and consumers preferences.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results and discussion of the findings. The result was in two folds which comprised the laboratory analysis to determine the nutrient and minerals present in the shrimps. The other part of the analysis is about the sensory evaluation on the un-powdered and powdered smoked shrimps which were evaluated by 88 panelists from Kumasi Technical University. The background information of the panelist/respondents has also been presented to give enough information to the readers. The results have been presented in tables for analysis and discussion.

Results from the Field

The results from the field which wass on the background information of the respondents have been presented in table for analysis. Also, results of four research objectives have been presented being assessment of the effect of smoking on nutritional value of shrimps, effects of fuel types on smoking shrimps, acceptability level of smoked shrimps as a whole or in powdered form and acceptability level of smoked shrimps with wood type. Two hypotheses were also addressed which were “there is no significant difference in the types of wood used for smoking with regards to nutritional and chemical properties of shrimps” and “there is no significant difference on shrimps smoked with selected wood types for smoking and consumers preference”.

Background information of Respondents

The background information on respondents has been presented in Table 1 for analysis and discussion.

Table 1: Background information of Respondents

Category	Frequency	Percentage
Gender		
Male	27	30.68
Female	61	69.32
Age (years)Range		
15-20	4	4.55
21-25	61	69.32
26-30	12	13.64
31-35	9	10.22
36-40	2	2.27
41-45	0	0
>45	0	0

Source: Field data, (Abankwah, 2020)

The result indicated that most of the panelists were females which were more than twice of the male panelists who took part in the study. The result thus implies that a lot of the females are pursuing Home Economics and its related programmes.

The participants have their ages ranged from 21-25 years. The mid age of the next highest 12 (13.64%) participants is 28 years. The average age of the students was 23years and this age represents mature people. The least number of 2 people were in the age range of 36 - 40 years. This implies they are adults that can make right decisions for themselves. However, looking at the result in Table 1 shows that there was no participant in the ages from 41 years and above.

Objective 1: Assessment of effects of smoking method on the nutritional value of shrimps.

The response to research objective one is done by presenting nutrients that have been analysed in the chemical laboratory after shrimps have been smoked by oven and different fuel types as presented in Table 2. The second fold of the data is the ANOVA result of the nutrients found in the analysed laboratory data as in Table 2.

Table 2: Nutrients present in smoked shrimps by oven and wood type

	Oven-smoked and with wood type			
Nutrient (%)	Control (Oven)	A (Emire)	B (Esia)	C (Okro)
Dry Matter	93.84±0.08	89.93±0.07	89.52±0.18	88.49±0.26
Moisture	6.16±0.08	10.08±0.07	10.48±0.18	11.51±0.26
Ash	21.39±0.09	19.85±0.24	22.05±0.05	21.26±0.39
Protein	57.38±0.31	58.48±0.66	59.24±0.29	58.27±0.39
Fibre	9.27±0.58	8.58±0.74	8.38±0.16	9.07±0.46
Fat/Oil	3.57±0.04	4.10±0.16	3.98±0.03	3.87±0.04
CHO	8.39±0.42	8.99±0.85	6.35±0.49	7.53±0.33

Source: Field data, (Abankwah, 2020) **Terminalia ivorensis* (Emire) **Petersianthus macrocarpus* (Esia) **Albizia zygia* (Okro)

Nutrient is the most important thing the body need for growth and healthy living. The result as presented in Table 2 was about shrimp preservation using oven and different woods as fuel for smoking. The oven serves as the control of the shrimps preservation by oven drying. Three different wood fuels have been used to smoke the shrimps and the data analysed to assess the effect of smoking using the fuel type on the nutrition status of the shrimps. The result indicated that there was seven different nutrients that can be found in the

laboratory analysis of the smoked shrimps. These includes dry matter, moisture, ash, protein, fibre, fat/oil and carbohydrate. The amount of quantity found with respect to each nutrient varies. The least mean value is 3.53 and this move up to a value of 93.92.

The mean result with respect to the dry matter for the control was more than the 'Emire', 'Esia' and 'Okro' by 3.91, 4.32 and 5.35 respectively. In terms of the fuel type without the control, the smoked shrimps have more dry matter when smoked with the 'Emire' and followed by 'Esia'. It can be noted that the moisture presence in the smoked shrimps was much higher in the fuel wood as compared to the oven smoked shrimps. The highest mean result of moisture in shrimps that were smoked with the wood types was for 'Okro' followed by 'Esia' and 'Emire' compared to the oven smoked shrimps. The mean difference between the most and the least is 5.53 in terms of the moisture content that determined in the shrimps during laboratory analysis. Also, the moisture content for the oven dried shrimps was 1.89 times lower to shrimps smoked with 'Okro' fuel. The mean ratio between 'Emire' and 'Esia' was almost one is to one (1.087:1.066) which was statically insignificant.

The mean ash content in the smoked shrimps ranged from 20.09 to 22.65. It can be seen from Table 2 that the mean ash presence increases across the table starting from the 'Emire' to 'Okro'. However, the mean value of the controlled smoked shrimps with respect to ash content fall within the increasing pattern of 21.48. It can also be observed that the mean values were close to each other. The variation is about ± 1.20 which suggests the difference was not much between the fuel type used for smoking the shrimps.

Protein perhaps is one of the essential nutrient that the human body needs to be healthy. The mean value of the protein found in the smoked shrimps ranges from 58.66 and 59.53. The least mean value of protein in the smoked shrimps was found in the oven smoked shrimps and the high mean values are all in found the wood fuel used for the smoking. The differences in the mean values of oven smoked shrimps as against 'Emire', 'Esia' and 'Okro' are 1.38, 1.77 and 0.9 respectively. The difference in mean value between oven smoked shrimps and that of 'Esia' is significant as compared to 'Okro' fuel type.

The percentage fibre presence in the smoked shrimps varies and this could be seen in the result presented in Table 2. For instance, the mean value of fibre in the oven smoked shrimps is 9.85 which vary from 9.53 to 8.54 as the least mean value. It could be observed that the mean values are packed or close to each other. This was clearly shown in the range of the figures to be 1.04 (i.e 9.85-8.54). The % Fat/Oil mean value ranges from 3.61 to 4.26 and the difference in this mean value of 0.65 which was close to 1. In terms of the wood type for the smoking, the mean value for 'Emire' was much high than that of the other two fuel types. The percentage carbohydrate that was present in the smoked shrimps has their means ranging from 6.84 to 9.84.

The mean results with respect to 'Esia' and 'Okro' are all less than the mean values of 'Emire' and the oven smoked shrimps. The mean difference between the oven smoked shrimps with respect to carbohydrate, the least mean value which was for 'Esia' is 1.97. It can be gleaned from the Table 2 result that the least mean values were recorded for moisture and Fat/Oil while the high mean values were conspicuous for dry matter and protein.

Table 3: Result of nutrients present in shrimps by oven and wood type smoked

Percentage (%)		Sum of Squares	df	Mean Square	F	Sig.
DM	Between Groups	49.33	3	16.44	595.25	.000
	Within Groups	.22	8	.03		
Moisture	Between Groups	49.33	3	16.44	595.25	.000
	Within Groups	.22	8	.03		
Ash	Between Groups	7.74	3	2.58	47.08	.000
	Within Groups	.44	8	.06		
Protein	Between Groups	5.29	3	1.76	9.15	.006
	Within Groups	1.54	8	.19		
Fibre	Between Groups	1.55	3	.52	56.16	.000
	Within Groups	.07	8	.01		
Fat/Oil	Between Groups	.47	3	.16	142.08	.000
	Within Groups	.01	8	.01		
CHO	Between Groups	11.76	3	3.92	12.57	.002
	Within Groups	2.49	8	.31		

Source: Field data, (Abankwah, 2020) **Terminalia ivorensis* (Emire) **Petersianthus macrocarpus* (Esia) **Albizia zygia* (Okro)

The result of the nutrients found in the smoked shrimps to determine the significance of the mean values has been presented in Table 3. The ANOVA result has indicated that all the nutrients were significant at $P<0.05$. The F-statistic for 'dry matter' and 'moisture' are the same which shows similarity and the two nutrients mean values were significant. The rest of the F-statistic was not the same throughout in Table 3. The sum of squares results between and

within the groups for each of the nutrients varies. It can therefore be concluded that seven nutrients; percentages (%) Dry Matter, Moisture, Ash, Protein, Fibre, Fat/Oil and CHO were found and all were significant.

Objective 2: Evaluate the effects of smoked shrimps using different type of woods.

In finding solution to the research objective two, descriptive statistics was used to analyse the result as presented in Table 3. The result has been presented in two folds to answer the objective two for analysis which are the descriptive and ANOVA results. The result has been presented as mean and standard deviation which were recorded in triplicates.

Table 4: Result of mineral present in oven-smoked and smoked with wood type

Mineral	Oven-smoked and Smoked with wood type			
	Control (Oven-smoked)	A (Emire)	B (Esia)	C (Okro)
Phosphorus	12291.96	11750.18	11309.69	11183.11
(ug/g)	±359.19	±106.89	±414.98	±181.48
Potassium	4681.08	4826.67	4793.34	4723.55
(ug/g)	±17.06	±15.87	±76.89	±60.32
Sodium	5304.29	5860.51	5591.91	5436.87
(ug/g)	±118.51	±182.21	±77.68	±29.17
%Calcium	3.56±0.01	3.61±0.08	4.75±0.08	3.88±0.033
%Magnesium	0.49±0.01	0.63±0.02	0.45±0.1	0.45±0.01

3

Source: Field data, (Abankwah, 2020) *Values are averages of triplicate determinations

*Data is represented as mean ± standard deviation **Terminalia ivorensis* (Emire) **Petersianthus macrocarpus* (Esia) **Albizia zygia* (Okro)

The result as presented in Table 4 shows that there was five different minerals that was found in the smoked shrimps. The mineral found were phosphorus, potassium, sodium, calcium and magnesium. The mean value for Phosphorus that has been found in smoked shrimps ranges from 11,364.59 to 12,651.15. The highest mean value recorded is for the shrimps that have been smoked in the oven to serve as the control. The mean value was in the excess of 794.08, 926.48 and 1,286.56 for 'Emire', 'Esia' and 'Okro' respectively with respect to the controlled mean values of the smoked shrimps. It could be gleaned that phosphorus quantity was more in the controlled smoked shrimp sample. In the case of potassium under the control smoked shrimps, the mean value for the control smoked shrimps was smaller than the mean value of the wood fuels. For instance, 'Emire' has of 4826.67 more than the control value which had a difference of 145.59. In respect to the fuel types, the mean value recorded were almost close ('Esia' & 'Okro') but with 'Emire', the mean value was much high.

The highest mean values for sodium present in the smoked shrimps was 60,000 plus and the least mean value of sodium was about 5,400. The least mean value was for the controlled smoked shrimps in the oven. The mean values for calcium and magnesium were in their once whiles the earlier analysed data were in thousands. The least mean value for calcium was 3.57 and the highest mean value was 4.83. In the case of magnesium, the least mean value 0.46 and its highest mean value that have been recorded was 0.65. It was gleaned therefore that in summing up all the mean values that was recorded for either calcium or magnesium would not be equated to even one value that was recorded for a given fuel type or the oven smoked shrimps.

The result is about the ANOVA analyses done on the presence of minerals found in the smoked shrimps.

Table 5: Result of minerals present in smoked with wood type and oven-smoked shrimps

		Sum of Squares	df	Mean Square	F	Sig.
Phosphorus (ug/g)	Between Groups	2264651.53	3	754883.84	8.74	.007
	Within Groups	691184.31	8	86398.04		
Potassium (ug/g)	Between Groups	39163.93	3	13054.64	5.17	.028
	Within Groups	20186.01	8	2523.25		
Sodium (ug/g)	Between Groups	514006.84	3	171335.61	12.66	.002
	Within Groups	108260.93	8	13532.62		
%Calcium	Between Groups	2.74	3	.91	228.95	.000
	Within Groups	.03	8	.04		
%Magnesium	Between Groups	.07	3	.02	159.01	.000
	Within Groups	.01	8	.00		

Source: Field data, (Abankwah, 2020)

The result as in Table 5 thus indicated that all the five minerals have their significant figures less than alpha value ($p<0.05$). The F-statistic for the minerals ranged from 5.2 to 228.5. However, the F-statistic values were not close except for Phosphorus and Potassium (8.7 and 5.2 respectively). It can therefore be concluded that the minerals that have been found in the smoked shrimps are of substantial quantity and the wood used for the smoking did not have any negative effect on the smoked shrimps. In addition as a confirmation, the mineral content in the smoked shrimps in Table 5 was confirmed to be of significant quantities.

Objective 3: Sensory evaluation of the acceptability level of smoked and un-powdered shrimps with different kinds of wood

Shrimps have been liked by many for its nutritional content and its nourishment to the human system. Shrimps have been used for stews, sauces, soups and varied kinds of meal when not powered. The study thus wants to determine if the kind of wood fuel used for the smoking of the shrimps actually have any effect on its acceptability. One-way ANOVA has been run for the shrimps that have been coded into three categories depending on the fuel used for the smoking.

Descriptive and the ANOVA results have been presented in Tables 6 and 7 for analysis. The acceptability of the un-powered smoked shrimps has been evaluated based on colour, taste, aroma and texture as the characteristics for the panelist to use for their assessment.

Table 6: Result of Acceptability of un-powdered smoked shrimps

Characteristics	Formulation	N	Mean	Std. Deviation
Colour	USTI	88	2.22	.988
	USPM	88	2.45	1.060
	USAZ	88	3.51	1.356
Taste	USTI	88	2.49	1.330
	USPM	88	2.52	1.184
	USAZ	88	3.64	1.416
Aroma	USTI	88	2.74	1.218
	USPM	88	2.77	1.036
	USAZ	88	3.27	1.201
Texture	USTI	88	2.65	1.322
	USPM	88	2.72	1.114
	USAZ	88	3.26	1.129
Overall Acceptability	USTI	88	3.33	1.362
	USPM	88	3.34	1.004
	USAZ	88	4.11	1.129

Source: Field data, (Abankwah, 2020)

The result indicated the colour characteristic for 'USAZ' has the highest mean value and standard deviation of 1.34 and the least mean being for 'USTI' (std.= 0.98). In the case of taste characteristic, the least mean value was for 'USTI' and standard deviation was 1.3 while the highest mean of 3.6 was for 'USAZ'. The low and high mean values with respect to aroma are 2.74 and 3.27 for 'USTI' and 'USAZ' respectively. Their standard deviations for the said formulations ('USTI' and 'USAZ') are 1.21 and 1.20 respectively.

In the case of texture as a characteristic for the assessment of the un-powdered smoked shrimps, 'USTI' had low mean value and the high mean value is for 'USAZ'. The ANOVA result as in Table 7 indicated that all the testable characteristics (colour, taste, aroma and texture) had their sig. value being less than 0.05 ($p<0.05$) except texture. This thus implies that colour, taste and aroma were significant and they were the characteristics the panelists dwell on most to accept or otherwise of the formulations. The overall acceptability result as in Table 7 has shown the most preferred un-powdered smoked shrimps to be 'USAZ'. The level of the un-powdered shrimps comes in order of their mean value magnitude (USTI<USPM<USAZ). On the basis of the analyzed results in Tables 6 through to 7, it can therefore be concluded that the panelists accepted 'USAZ' formulation the most with a mean score of 4.11.

Table 7: Acceptability of un-powdered smoked shrimps

		Sum of Squares	df	Mean Square	F	Sig
Colour	Between Groups	83.659	2	41.830	31.857	.000
	Within Groups	342.705	261	1.313		
Taste	Between Groups	75.053	2	37.527	21.751	.000
	Within Groups	450.307	261	1.725		
Aroma	Between Groups	15.735	2	7.867	5.902	.003
	Within Groups	347.898	261	1.333		
Texture	Between Groups	19.909	2	9.955	7.004	19.91
	Within Groups	370.966	261	1.421		370.97
Overall Accepta-bility	Between Groups	35.553	2	17.777	12.885	.000
	Within Groups	360.080	261	1.380		

Source: Field data, (Abankwah, 2020)

Table 8: Overall Acceptability of Un-powdered Smoked Shrimps

		Subset for alpha = 0.05	
Formulations	**N**	**1**	**2**
USTI	88	3.33	
USPM	88	3.34	
USAZ	88		4.11

Source: Field data, (Abankwah, 2020) *Post Hoc Tests: Tukey B[a] ** Uses Harmonic Mean Sample Size = 88.000.

Objective 4: Sensory evaluation of the acceptability level of smoked and powdered shrimps with different kinds of wood.

Shrimps have been liked by many for its nutritional components and its flavor in 'shito' and stew. Shrimps have been used for stew or soup for varied kinds of meal when powered. The study thus sought to determine if the kind of wood fuel used for the smoking of the shrimps actually have any effect on its acceptability when powered. One-way ANOVA has been run for the shrimps that have been coded into three categories depending on the fuel used for the smoking. Descriptive and the ANOVA results have been presented in Tables 9 and 10 for analysis. The acceptability of the powered smoked shrimps has been

evaluated based on colour, taste, aroma and texture for the basis of the panelists to use for their assessment.

Table 9: Descriptive Result of smoked Powdered Shrimps

	Formulation	N	Mean	Std. Deviation
Colour	PSTI	88	2.76	1.174
	PSPM	88	2.89	1.139
	PSAZ	88	3.36	1.243
Taste	PSTI	88	2.63	1.216
	PSPM	88	2.67	1.162
	PSAZ	88	3.30	1.279
Aroma	PSTI	88	2.75	1.215
	PSPM	88	2.76	1.145
	PSAZ	88	3.30	1.074
Texture	PSTI	88	2.95	1.203
	PSPM	88	2.78	1.066
	PSAZ	88	3.07	1.172
Overall Acceptability	PSTI	88	3.45	1.249
	PSPM	88	3.45	1.113
	PSAZ	88	4.14	.973

Source: Field data, (Abankwah, 2020)

The powdered smoked shrimps that has been tested using one – way ANOVA as presented in Table 9 has indicated colour characteristic for 'PSTI' and 'PSAZ' has low and high mean score of 2.7 and 3.3 respectively. The taste characteristic recorded the low mean of 2.6 and highest mean of 3.3 for 'PSTI' and 'PSAZ' respectively. A low mean value of 2.75 for 'PSTI' and high mean value 3.30 for 'PSAZ' for aroma characteristic for the smoked powdered shrimps. The texture for the powdered shrimps had a low mean of 2.78 for 'PSPM' and the high mean score of 3.07 for 'PSAZ'.

The ANOVA result in Table 10 indicated that all the testable characteristics (colour, taste, aroma and texture) have their Sig. values being less than 0.05 ($p<0.05$) except texture. This thus implies that colour, taste and aroma were significant and they were the characteristics the panelists dwell on

most to assess the acceptability or otherwise of the formulations. The overall acceptability result as in Table 11 has shown the most preferred powdered smoked shrimps to be 'PSAZ'. The level of the powdered shrimps comes in order of their mean value magnitude (PSTI ≤PSPM<PSAZ). On the basis of the analyzed results in Tables 9 through to 11, it can therefore be concluded that the panelists accepted 'PSAZ' formulation the most with a mean score of 4.14.

Table 10: ANOVA Result of Powdered smoked Shrimps

		Sum of Squares	df	Mean Square	F	Sig
Colour	Between Groups	17.780	2	8.890	6.319	.002
	Within Groups	367.216	261	1.407		
Taste	Between Groups	24.705	2	12.352	8.301	.000
	Within Groups	388.386	261	1.488		
Aroma	Between Groups	17.098	2	8.549	6.509	.002
	Within Groups	342.807	261	1.313		
Texture	Between Groups	3.598	2	1.799	1.364	.257
	Within Groups	344.307	261	1.319		
Overall Acceptab-ility	Between Groups	27.273	2	13.636	10.917	.000
	Within Groups	326.000	261	1.249		

Source: Field data, (Abankwah, 2020)

Table 11: Overall Acceptability Result of Powdered smoked Shrimps

		Subset for alpha = 0.05	
Formulations	**N**	**1**	**2**
PSTI	88	3.45	
PSPM	88	3.45	
PSAZ	88		4.14

Source: Field data, (Abankwah, 2020)

Post Hoc Tests: Tukey B[a] * Uses Harmonic Mean Sample Size = 88.000.

Hypothesis 1

H_0: There is no significant difference in the types of wood used for smoking with regards to nutritional and chemical properties of shrimps.

In testing this hypothesis, the mean value of nutrients and minerals present in the smoked shrimps when a particular wood type was used have been

computed and analysed using One-way ANOVA. The result has been presented in Tables 12 and 13. The result in Table 12 is the mean and standard deviation to give clear idea of the result while the ANOVA result in Table 13 is to help in drawing conclusion.

Table 12: Nutritional and Chemical properties of shrimps smoked with wood type

Variables	Fuel (wood) Type	N	Mean	Std. Deviation
Nutrient	A (Emire)	3	28.571	.000
	B (Esia)	3	28.571	.000
	C (Okro)	3	28.571	.000
Chemical	A (Emire)	3	4,488.319	20.226
properties	B (Esia)	3	4,340.029	80.290
	C (Okro)	3	4,269.571	53.244

Source: Field data, (Abankwah, 2020) **Terminalia ivorensis* (Emire)
**Petersianthus macrocarpus* (Esia) **Albizia zygia* (Okro)

The result as presented in Table 12 indicated that 'Emire' had a mean of 28.57 with standard deviation of 0.00 and the same figure had been recorded for 'Esia' and 'Okro' as well all with respect to the nutrient that has been found in the smoked shrimps. In the case of the minerals present, the figures recorded for the fuel types varied considerably. The least mean score that has been recorded is for 'Okro' and the most mean score for 'Emire' is 4,488.32. The mean score goes with the standard deviation values as it can be seen from the result presented in Table 1. It can be gleaned from the result that the mean scores for the nutrients were small as compared to the mean scores for the mineral for each of the wood fuel used in the smoking.

Table 13: ANOVA Result on nutritional and chemical properties of smoked shrimps with wood type

Variables		Sum of Squares	df	Mean Square	F	Sig.
Nutrient	Between Groups	.000	2	.000	.312	.743
	Within Groups	.000	6	.000		
Chemical properties	Between Groups	74805.218	2	37402.609	11.579	.009
	Within Groups	19380.981	6	3230.163		

Source: Field data, (Abankwah, 2020)

The ANOVA result presented in Table 13 has F-value of 0.312 with significant value of 0.74 has indicated the result is not statistically significant ($p>0.05$) with respect to the nutrients found in the smoked shrimps. The F-statistic for the chemical properties present in the smoked shrimps is 11.58 and its significant value being 0.009. The result thus shows that the significant value found is less than alpha value of 0.05 ($p<0.05$). The result thus was statistically significant. It can therefore be concluded from the analysis of the results in Tables 12 and 13 that there was a significant difference in the types of wood used for smoking; the nutritional and chemical properties. The null hypothesis is therefore rejected in favour of the alternative hypothesis.

Hypothesis 2

H_0: There is no significant difference on shrimps smoked with selected wood types for smoking and consumers preference.

In testing hypothesis 2, the mean value of smoked shrimps with a given wood type used for smoking and the One-way ANOVA result has been presented in Tables 14 and 15 respectively. The result in Table 14 used the entries the panelists have given after they have assessed the smoked shrimps with a given fuel type.

Table 14: Acceptability of smoked shrimps with wood type

	N	Mean	Std. Deviation	Std. Error
STI	88	3.33	1.362	.145
SPM	88	3.34	1.004	.107
SAZ	88	4.11	1.129	.120
Total	264	3.59	1.227	.075

Source: Field data, (Abankwah, 2020)

The acceptability of the Panelists as in Table 14 shows that the mean score of the various samples (STI, SPM and SAZ) varies from 3.33 to 4.11. The least mean score (3.33) is for 'STI' which had a standard deviation of 1.36 while the high mean score (4.11) is for 'SAZ' which also have a standard deviation of 1.13. In Table 15, the result clearly indicated that there is a significant difference between the groups and within the groups. Thus the F-statistic recorded a value of 12.89 and a significant value of 0.00 ($p<0.05$).

Table 15: ANOVA Result on wood type for smoked shrimps

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35.553	2	17.777	12.885	.000
Within Groups	360.080	261	1.380		
Total	395.633	263			

Source: Field data, (Abankwah, 2020)

Table 15 presents the ANOVA results on the wood types for smoking shrimps.

Table 16: Shrimp preference by wood type used for smoking

		Subset for alpha = 0.05	
Formulations	**N**	**1**	**2**
STI	88	3.33	
SPM	88	3.34	
SAZ	88		4.11

Source: Field data, (Abankwah, 2020)

The result in Table 16 has ranged the mean score per the significant value. The result shows that the most accepted smoked shrimps that have been smoked with a given wood type is 'SAZ'. This acceptance was followed by 'SPM' and 'STI' respectively (STI<SPM<SAZ). It can in this manner be inferred that there is a significant difference on shrimps smoked with a given wood type. The null hypothesis is therefore rejected in favour of the alternative hypothesis.

Discussion of Results

The finding from the first objective is that all the nutrients found in the smoked shrimps were all significant. This is an indication that smoking as a way of preservation has not destroy the essential nutrients in the shrimps. Heat is mostly known to kill bacterial and other pathogenic organism that could lead to the spoilage of fresh fish and other sea foods like shrimps. It is therefore heartwarming to find from this study how heat or smoking of shrimps did not destroy the needed nutrients for the body when it is consumed.

The result thus confirmed the earlier study of Akintola (2015) that hot smoking does not destroy the essential nutrients like protein and carbohydrate in shrimps. The ash, dry matter, fibre, fat/oil and carbohydrate have also been found in the current study to be intact in addition to protein as found by Akintola (2015). The result in the current study has clearly shown that all the nutrients found are significant. This therefore suggested that when someone consumes smoked shrimps by using *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia) and *Albizia zygia* (Okro) is assured of getting the needed nutrients for the proper functioning of the human body.

The result has confirmed what Hog, Islam and Kamal (2008) that quality of traditional smoked product is quite good. All the nutrients found in the current study were high ($p<0.05$) as noted by Akintola (2015). The protein content in the current study ranged from 57.38±0.31 to 59.24±0.29 which is far higher that what was found by Akuamoa, Odamtten and Kortei (2018) to range from 27.40 ± 1.30% to 34.35 ± 1.30%.

In the case of the ash presence in smoked shrimps, the quantity found in the study of Akuamoa *et al.* (2018) was lower (13.80 ± 0.09% to 15.42 ± 0.09%) than what has been found in the current study (19.85±0.24% to 22.05±0.05%). Similar trends of low quantities of moisture and fat was found in the study of Akuamoa *et al.* (2018) which are 9.36±0.06% to 12.92±0.06% ; and 0.90±0.01% to 1.72±0.01% for moisture and fat/oil respectively. This result is pointing to the fact that the fuel type used for the smoking did not destroy any nutrients in the shrimps.

One of the cardinal means to prevent constipation in human is to eat a lot of food that have fibre. The study has found significant quantity of fibre in the smoked shrimps. This therefore implies that anyone that consumes smoked shrimps would have more fibre or roughage in their food. Roughage in general helps in proper digestion of foods. A person consuming smoked shrimps is not only getting protein, fat/oil, carbohydrate and other nutrients but is going to improve the digestion process of food that has been consumed.

Easy digestion of food would go a long way to prevent diseases that are associated with constipation. The nutritional composition of the smoked shrimps in this study is therefore an eye opener to the fact that varieties of wood for smoking especially *Terminalia ivorensis* (Emire), *Petersianthus*

macrocarpus (Esia) and *Albizia zygia* (Okro) is good in preventing the destruction of essential nutrients that can aid the metabolism of digestion.

Moisture is also good for digestion and other metabolic activities in the body. The moisture found in this study was very encouraging as compared to what was found in Akintola (2015). The human body in general have about 70% as fluid in the system which the body make use of. Having much presence of moisture in the smoked shrimps would also in a way add to the body fluid needs when consumed. The consumption of smoked shrimps can be said to promote the general health of persons that use it in preparing meal. This is hypothetically so in view of the nutritional compositions in the smoked shrimps.

On research objective two, the study revealed that five different mineral were present in the smoked shrimps which were phosphorus, potassium, sodium, calcium and magnesium. British Nutrition Foundation (2017) has found that some minerals are needed in large quantities and the result in this study supported that assertion. The amount of Phosphorus found in this study was generally large as compared to the other minerals that have been found. For instance, the presence of calcium and magnesium quantities was few in relation to the quantity in phosphorus, potassium and sodium. In any case, the body does not need same quantity of minerals to be small or more for the body parts to function. In the case of adult human beings their need of calcium diminishes as the body grows but in the case of children, they would need much of calcium for the teeth and bone development. These minerals have been found to be present in the smoked shrimps either powdered or un-powdered.

The smoked shrimps or shrimps in general are packed with minerals and vitamins that the body could make use of. The minerals that are present in

the shrimps are all good for all categories of humans being from toddler or adult. Smoked shrimps can be un-shelldered (removed shell) and served to both children and adults. Instead, it would help to improve the body function of the human cells to fight against diseases.

The minerals found in the smoked shrimps are valuable to the human development. For instance, calcium was found in much quantity which helps to formation of strong bone, teeth formation and among others. The human bone and teeth though not so visible outside, it plays a role for the body that makes it movement and feeding possible. Vitamin deficiency is noted to create chronic health conditions (Andrews, 2014; Higdon, 2003) therefore the presence of found minerals in the shrimps would help individuals to assimilate what is needed for the body. Most diseases are health related issues as a result of poor dieting and lack of the needed vitamins and minerals in the food consumed. Shrimps are used in preparing 'shito' and other dishes hence, its use would provide what the body needs in terms of vitamins and nutrients.

The heat as generally reported does destroy some nutrients and vitamins in food during processing. The result as found suggests that heat has actually reduced the amount of mineral presences in the smoked shrimps. The values of mineral presence in the controlled smoking were all low as compared to the values obtained when wood fuel has been used. It's therefore conspicuous that heat actually reduces the quantity of minerals that have been found. In lowering the amount or quantity of minerals during smoking and a preservative measure thus has to be re-looked at by adopting or researching in other ways that could minimize or prevent the minerals lost during hot smoking. Shrimps as known

by most people is a perishable food that needs to be preserved to last for its normal shelf life.

What is likely to happen is that though people may be consuming shrimps, the exact quantity of specified minerals may not be available in the smoked shrimps. Consuming smoked shrimps that could not provide what exactly the body needs for its function are just amount to eating junk shrimps.

The result on acceptability of un-powdered smoked shrimps revealed that most of the panelists accepted 'USAZ' as their preferred product. Most people use unpowered shrimps to prepare foods such as soups, stews and so on.They do appreciate it much than the powdered fish or shrimps.

Research objective four which was on the sensory evaluation of the acceptability level of smoked and powdered shrimps with different kinds of wood has been analyze. The result thus revealed that panelists accepted 'PSAZ' formulation more than other two formulations. Children who are wined or have been wined did not have their teeth well developed hence cannot eat fish, meat and other animal source of protein. Therefore, alternative means of getting protein for them is very necessary. Pounding smoked shrimps could be one of the ways to make the shrimps easily to be consumed by children. In the preparation of 'shito' too, henrrings and shrimp are most at times combined or used separately for the needed impact so desired by the person preparing it.

The shells of the shrimps also are a source of calcium which is good for the body. The immune system of the human body is good to protect and fight diseases that threaten it. The consumption of balanced diet alone is assured of providing what the body needs to stay healthy. The use of shrimps in 'shito' preparation will not only provide protein, but a whole lot of minerals that the

body needs to perform to its maximum. The panelists use taste, colour, texture and aroma being the parameters used for selecting 'PSAZ' formulation as the most preferred. The aroma and taste of food could be said to contribute about 90% to persons prefrence a given food. The panelists having convinced themselves about what they preferred thus aggregate in favour of 'PSAZ' product.

Hypothesis one focused on the significant difference in the types of wood used for smoking with regards to nutritional and chemical properties of shrimps. The result clearly established the fact that there is a significant difference in the type of wood used for smoking with relation to nutrients and chemical properties found in the shrimps. Although the type of wood used in doing the smoking would not add any nutrients or chemical properties to the smoked shrimps, it could rather destroy some portions of the nutrients and chemicals available in the smoked shrimps. Every wood and its quality of heat or fire depends on its intensity, this has therefore informed people in the rural areas where smoking of fish is done as a source of their livelihood know what kind of wood to select in doing their smoking of fish or shrimps. The smokes from some fuel woods are poisonous so the traditional people do not use such woods. Despite the low level of formal education especially in science of some indigenous people, they have experimented on this over the years and can tell the effect though in a painful way.

The smoke from woods add colour to the smoked shrimps that gets people attracted to it. It is believed that the colour change of the shrimps due to the kind of wood used to do the smoking. The wood used also could add a special taste or in other words, alters the taste of the smoked shrimps. Some

woods naturally produce smoke that are pleasant to the nose and if such woods are used in doing the smoking, it would add such an aroma to the shrimps. Smoking also reduces its most soluble proteins such as myofibrillar and sarcoplasmic component and raises the quantity of unsolvable protein, as per Chavan et al . (2008). The smoke in this case was seen from the result not have affected the end product of the shrimps.

Friedman (1996) further found that the physical depletion of lipids, amino acids and micronutrients resulted in fats and much more water drops from the fish mostly during smoking process. This has been confirmed in this study by reducing the lipids in the shrimps. The weight of the shrimps after smoking has generally reduced in view of the drip lipid during the smoking process. This was also evident to that fact that, the fire or smoke makes a sound during the smoking process. The reduction of the amount of lipid in the shrimps thus help in reducing the effect of pathogens effect on the shrimps which could be a fertile ground for them to feed and introduce poison into the shrimps to cause its spoilage. The root cause of spoilage is micro-organisms (Gram & Dalgaard, 2002), and pathogens may well be found (Huss et al., 2000).

The whole idea in the first place of smoking shrimps is to reduce its spoilage time and keep it a bit longer on the shelf. Specific spoilage bacteria produce ammonia, biogenic amines, organic acids, and sulphur compounds from acids, hypoxanthine from ATP and acetate from lactate (Swant, 2012). Spoilage organisms produce off odour volatile base compounds from nitrogen compounds (Swant, 2012). Preserving shrimps for a longer period is for the interest of the fisherman and the end consumers. The use of different woods in doing the smoking is an addition of other advantage to attract customers and the

ability to sell more of the shrimps. The taste might not be nice but the aroma alone becomes a drawing factor to the shrimps. The person would have finished chewing the shrimps before knowing whether it tastes sweet or otherwise. Aroma of food in this case, shrimps might put the panelists mind in the positive appreciation to accept the shrimps even before tasting them. This could put the panelists in awkward position to tell which product to choose first after they have smelt the aroma.

The result in hypothesis two which was test if there is a significant difference on shrimps smoked with selected wood types for smoking and consumers preference had revealed that there is a significant difference between smoked shrimps with fuel type and the consumers' preference. Women go to market looking for a particular product to buy but cannot find. The alternative is never their choice all because they knew what they are looking for. The fuel type used to smoke shrimps gives it a particular aroma and its looks. Consumers would be queuing to buy what they need while other product sellers have nobody to buy their wears or goods. This thus tells how consumers appreciate good things. If a product is not good, customers would just not patronize it. The good products normally sell itself to the general public. This therefore implies that most people would prefer to buy a particular smoked shrimps that have been smoked with a particular fuel type.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary, conclusions and recommendations the study arrived at. It also gives suggestions for further studies.

Summary

Food preservation is one of the important aspects of farming else, the work of the farmer would go waste. Shrimps as part of the decapod crustacean family in the seas and fresh water bodies need to be preserved to last longer after they have been caught else they would go bad. In the process of preserving shrimps, some of its attributes could be affected or changed due to the type of the preservative method. The premise of this was the basis for the study. The study therefore was to assess the effects of smoking on the quality attributes of shrimps in Ghana.

The study was guided by four research objectives and two hypotheses. Literature has been reviewed on the study to put the entire work into perspective and have better understanding on what have been done already on the topic. The literature review was in two distinct parts though all were geared towards a common goal of knowing what has been done and build the current study on them. The first part of the literature was the conceptual framework of the study followed by the theoretical review. The second part of the study was on the empirical review of the study which took into consideration the research objectives and the hypotheses.

The study adopted experimental research design. The design allowed for the manipulation of the variables and the location of the study was in Kumasi. Meanwhile the shrimps were obtained from the Atlantic Ocean in Cape Coast

area. A sample of 88 panelists was sampled from Kumasi Technical University students by using Krejcie and Morgan (1970) table of sampling. The smoked shrimps were sent to the chemical laboratory for analysis. Five–point Hedonic scale was self-designed to collect data from the panelists with respect to sensory evaluation.

Key Findings

The study has revealed the following.

1. Seven nutrients; %Dry Matter, %Moisture, %Ash, %Protein, %Fibre, %Fat/Oil and %CHO were found and all were significant.
2. Woods; *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia), and *Albizia zygia* (Okro) used for the smoking did not have any negative effect on the minerals in the smoked shrimps.
3. Panelists accepted 'USAZ' formulation as the most preferred product with a mean score of 4.11(USTI<USPM<USAZ).
4. Panelists accepted 'PSAZ' formulation as the most preferred product with a mean score of 4.14 (PSTI ≤PSPM<PSAZ).
5. There is a significant difference in the types of wood used for smoking with regards to nutritional and chemical properties of shrimps.
6. There is a significant difference on shrimps smoked with selected wood types for smoking and consumers preference.

Conclusions

Smoking as a method of preserving shrimps using different types of wood is very welcoming to the fishery industry especially the indigenous people. using *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia) and *Albizia zygia* (Okro) for smoking would not pose any difficulty to the fish mongers since these woods are common to the people. The study has made the problem for the study clearer and explains why the local people do not just use any type of wood to their smoking. What actually matters is how to put this findings into a better economic activities that could cause positive change in the financial status. Knowing the wood that gives better flavour or aroma to smoked shrimps is a way of presenting finished products to consumers and marketing it would be less difficult and expensive as well. In the traditional settings, bark of trees are used for medication and it is believed that using such trees as fuel to do smoking also helps the body in a way.

Nutrients and minerals found in the smoked shrimps is a plus to people who consume them often either in dishes or without. Depending on shrimps especially the smoked ones would go a long way to provide the needed mineral and nutrients the body would use. The human system therefore builds up its immune system to fight diseases which would have been treated with orthodox medicines.

Recommendations

1. The nutrients that have been found in percentages (%) (Dry Matter, Moisture, Ash, Protein, Fibre, Fat/Oil and CHO) are essential to the human system. Therefore, it is recommended that fishermen catch more shrimps and people encouraged through education by food nutritionists that have been attached to health facilities in its catchment areas. The consumption would also help to save more money for the persons concerned since less or no medication would be needed to treat any ailments.
2. *Terminalia ivorensis* (Emire), *Petersianthus macrocarpus* (Esia), and *Albizia zygia* (Okro) used for smoking has no side effect on the nutrients in the smoked shrimps. The local communities are to be encouraged to plant more of such trees for their own use. The agric-extension officers that have been attached to farming communities by government should be contacted to identify the woods so that they can be grown into woodlots for the people to depend on. This would therefore minimize deforestation and its associated problems.
3. The sale of 'USAZ' should be encouraged in the local market so that customers could have access to them to buy. Since it is the most preferred smoked shrimps that have been accepted.
4. More of 'PSAZ' has to be sold in the local market and people have especially the youth has to learn packaging of 'PSAZ' so that it could be distributed to super markets and other shops for people to buy for their consumption.

5. Every wood used in doing smoking has its impact on the nutrition of the shrimps therefore care must be taken not to use any wood for fuel in smoking shrimps.
6. Consumers would be on the look out for shrimps that have been smoked with a particular wood due to its aroma. Hence, fishmongers should be educated on this by environmental agencies, food and drugs authority and other food specialists to use such woods. The use of a particular wood would encourage the consumption of the smoked shrimps due to its aroma and even its taste.

Suggestion for further Research

The study has been on hot smoking in assessing the effect on the quality attributes of the shrimps in Ghana with a limit to three different woods for fuel. Its therefore recommended that a further study be conducted and expand the types of wood for smoking and impact on health of the smoked shrimps consumers in Ghana.

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APPENDICES

APPENDIX A

UNIVERSITY OF CAPE COAST

SENSORY EVALUATION QUESTIONNAIRE

The purpose of this evaluation was to collect data to examine the effects of smoking process on the quality of attributes of shrimps in Ghana. The study is for academic purpose hence, the information given will be used as such. Your candid response would be of immense help to the study. Any information given would be for the intended purpose and be assured that your identity would not be revealed under any circumstance.

Date……. Panelist ID……

Background Information of Respondent

Please **tick** [√] your age range

Age (years): 15-20 [ ] 21-25 [ ] 26-30 [ ] 31-35 [ ] 36-40 [ ]

41-45 [ ] 46 and above [ ]

Please circle your **gender**

Gender: Male Female

INSTRUCTION FOR THE EVALUATION

1. Please take a drink of water before tasting.
2. Assess the un-powdered shrimps and powdered shrimps in the order presented (from left to right).
3. Please remember to rinse your mouth with the water and spit into the cup provided before testing each of the samples.
4. With a tick, score each sample using the **numbers 1 - 5** to grade the attribute of each sample according to your preference in the table below.

Evaluation of Un-powdered shrimps

Please write the value/figure in a box to indicate your preference

Unlike =1, like =2, like slightly =3, like much =4, like very much = 5

Coded sample	Colour	Taste	Aroma/ Flavour	Texture	Overall Acceptability
USTI					
USPM					
USAZ					

Comments:……

……

……

……

Evaluation of Powdered shrimps

Please write the value/figure in a box to indicate your preference

Unlike =1, like =2, like slightly =3, like much =4, like very much = 5

Coded sample	Colour	Taste	Aroma/ Flavour	Texture	Overall Acceptability
PSTI					
PSPM					
PSAZ					

Comments:……

……

……

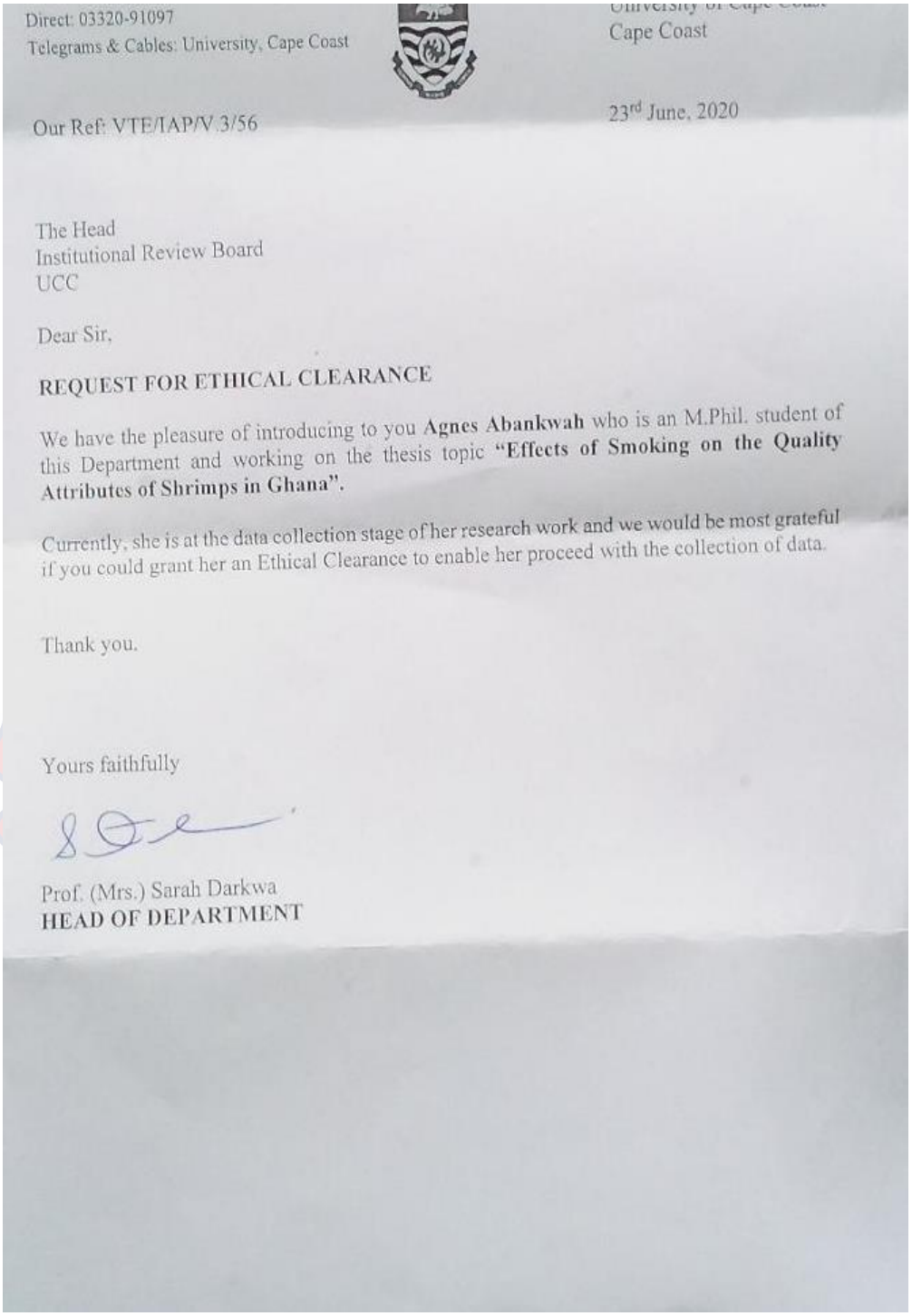
……

Thank you for your participation

APPENDIX B

UNIVERSITY OF CAPE COAST

REQUEST FOR CLEARANCE



Direct: 03320-91097
Telegrams & Cables: University, Cape Coast

University of Cape Coast
Cape Coast

Our Ref: VTE/IAP/V.3/56

23rd June, 2020

The Head
Institutional Review Board
UCC

Dear Sir,

REQUEST FOR ETHICAL CLEARANCE

We have the pleasure of introducing to you **Agnes Abankwah** who is an M.Phil. student of this Department and working on the thesis topic **"Effects of Smoking on the Quality Attributes of Shrimps in Ghana".**

Currently, she is at the data collection stage of her research work and we would be most grateful if you could grant her an Ethical Clearance to enable her proceed with the collection of data.

Thank you.

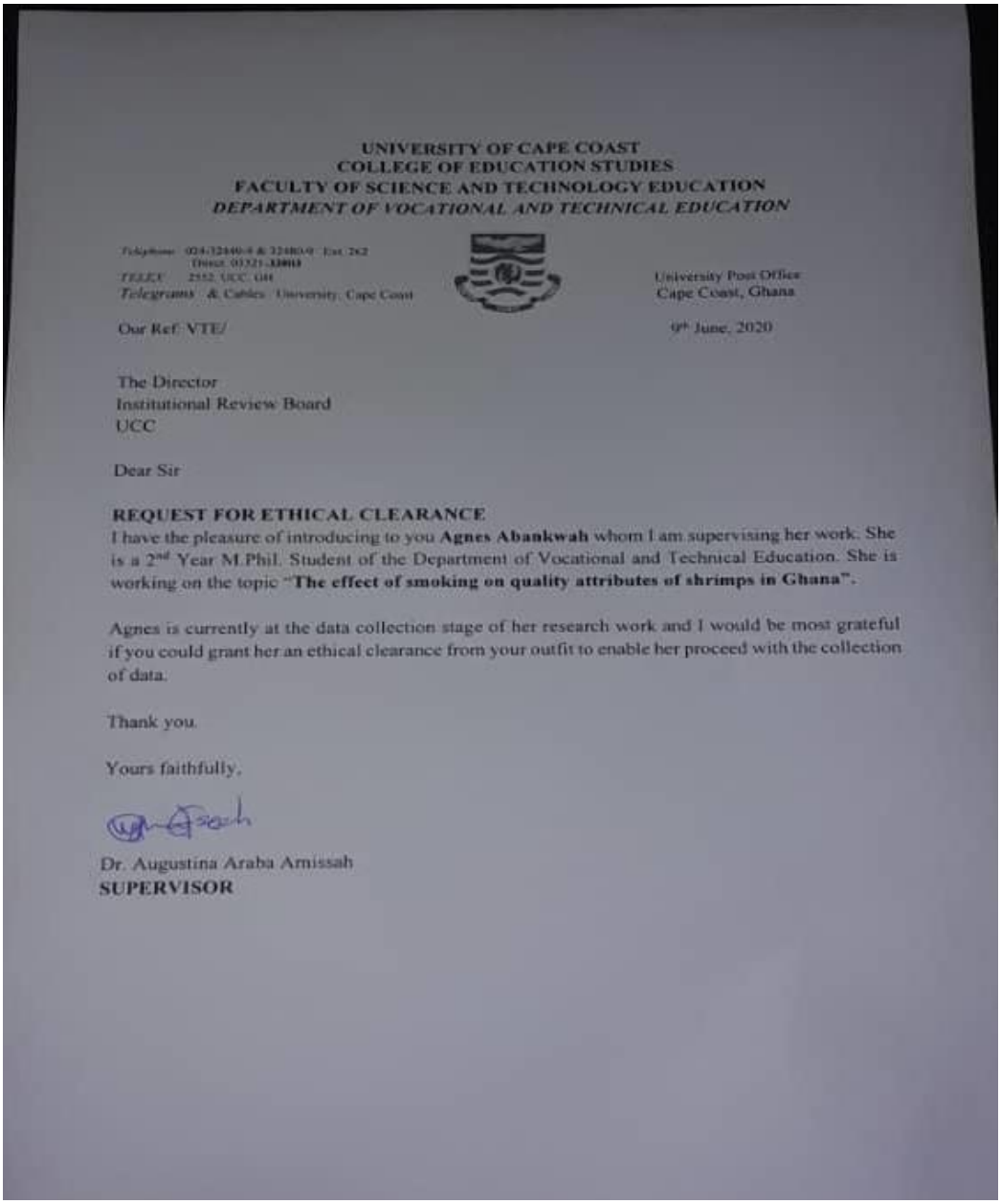
Yours faithfully

Prof. (Mrs.) Sarah Darkwa
HEAD OF DEPARTMENT

APPENDIX C

UNIVERSITY OF CAPE COAST

REQUEST FOR ETHICAL CLEARANCE



UNIVERSITY OF CAPE COAST
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FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
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9th June, 2020

The Director
Institutional Review Board
UCC

Dear Sir

REQUEST FOR ETHICAL CLEARANCE

I have the pleasure of introducing to you **Agnes Abankwah** whom I am supervising her work. She is a 2nd Year M.Phil. Student of the Department of Vocational and Technical Education. She is working on the topic "**The effect of smoking on quality attributes of shrimps in Ghana**".

Agnes is currently at the data collection stage of her research work and I would be most grateful if you could grant her an ethical clearance from your outfit to enable her proceed with the collection of data.

Thank you.

Yours faithfully,

Dr. Augustina Araba Amissah
SUPERVISOR

APPENDIX D

UNIVERSITY OF CAPE COAST

ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST
INSTITUTIONAL REVIEW BOARD SECRETARIAT
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OMB NO: 0990-0279
IORG #: IORG0009096
C/O Directorate of Research, Innovation and Consultancy

22ND SEPTEMBER, 2020

Ms. Agnes Abankwah
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Abankwah,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2020/64)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol **Effects of Smoking on the Quality Attributes of Shrimps in Ghana.** This approval is valid from 22nd September, 2020 to 21st September, 2021. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST