KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

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DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

EVALUATION OF PEANUT PASTE IN SELECTED MARKETS IN NORTHERN GHANA

BY

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DECLARATION

I hereby declare that the experimental work described in this thesis was performed by me at the Food Science and Technology Laboratory of the Kwame Nkrumah University of Science and Technology, Kumasi, under the supervision of Prof Ibok Oduro and Prof William Otoo Ellis towards the MSc (Food Science and Technology) degree. I certify that, to the best of my knowledge, this work has not been submitted for the award of any other degree of the University, except where due acknowledgement has been made in text

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DEDICATION

I dedicate this entire work to my family and friends, my supervisors, the Ghana PMIL (PEANUT AND MYCOTOXIN INNOVATION LABORATORY PROJECT), staff of the CSIR-SARI and the entire 2014-2015 MSc Food Science and Technology class of the KNUST-Kumasi

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ABSTRACT

Peanut paste is a delicacy in Ghana, but issues about its production quality in Northern Ghana, has been a challenge in recent times. The study aimed to assess peanut paste quality in Northern Ghana. Peanut paste samples (24) were acquired from six major markets. A control sample, using *Nkate-sari* variety of peanut was prepared in the Food Science and Technology Laboratory of the Kwame Nkrumah University of Science and Technology. A survey was conducted using structured questionnaires to understand the processing methods used. Proximate, aflatoxin and microbial load of the samples were also determined. From the survey, 75% of the producers used untreated stream water during processing. There was no sorting, grading or blanching during processing. The traders (96%) acquire raw peanuts from the market already de-shelled. Moisture, Crude protein and Carbohydrate content of the samples ranged from 5.05 ± 0.07 to 6.45 ± 0.21, 23.67±0.05 to 31.56 ±0.78 and 19.44 ±1.19 to 27.65 ±0.96 respectively. Statistical analysis showed no significant difference ($p>0.05$) between ash, carbohydrate and protein content. Aflatoxin analysis of the *Tamale* central, *Bolga* central, *Wa Gonomuni*, *Tamale Aboabu* and *Wa* central market samples showed concentrations of 2.89 ppb, 8.6 ppb, 55.39 ppb, 103.44 ppb and 126.55 ppb respectively. Total aerobic count ranged from 2.5×10^3 cfu/g to 9.9×10^3 cfu/g. Coliform count were below the acceptable limit of 10 cfu/g. Fungal enumeration was less than 10^1 cfu/g in all samples except for *Navrongo* central market samples. *Aspergilus parasiticus* was isolated in *Wa gonomuni*, Wa central market and *Tamale Aboabu* market samples respectively. *Blastomyces Dermatitidis* was found in *Bolga* central market samples. Even though

some samples had high nutrient composition, contamination levels were significant due to poor production practices.

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND OF STUDY

Peanut (*Arachis hypogaea*) is a leguminous crop ranked as the 13th most important food crop and 4th important oilseed crop in the world after soybean, cottonseed and rapeseed (Li *et al*., 2011). Peanuts are cultivated globally, especially in developing countries, where it constitutes about 97% of the total land area under cultivation and 94% of the global production (Craufurd *et al.*, 2006). The major producers of peanut, also known as groundnuts are China, India, Mali, Ghana and Nigeria (Mudenda, 2013). They are also widely consumed in Central and South America (Johanson & Ives, 2000).

About 80 % of Ghanaians from Northern Ghana consume peanut and peanut products out of which 32% consumes it as many as three times in a week (Yussif, 2014). The intake of peanut and its products such as peanut butter is increasing daily in the Northern part of Ghana (Tsigbey & Braderngurg, 2004). The production and sales of peanut and its product (peanut paste) serves as a major source of livelihood to the women in Northern Ghana (Millar & Yeboah, 2006).

Peanut paste is a very important product in the world, it can be used as condiment or for the preparation of soup (Katz, 2005). It's butter is also a good source of protein, fat, carbohydrate, fiber and minerals and has longer shelf life, smoothness and a very pleasant flavor (Chow, 2007).

According to Fraser *et al*., (1992), frequent peanut paste consumption can reduce the incidence of coronary heart diseases by 25 to 50 %. Consumption of peanut snacks daily

is important to the health of the individual since it contains other nutrient essential to the human systems development (Hu *et al.,* 1998). Peanut paste can therefore serve as a good product for the control of type 2 diabetes when consumed frequently or incorporated daily into meals (Jiang *et al*., 2002).

Although peanut is the most important leguminous crop cultivated in Ghana (Tsibgey, 2003), with major productions in the Northern part of the country, almost all of the peanuts grown are for domestic purposes. This may be attributed to the high prevalence of microbial and toxic metabolite contamination. This has particularly become dominant due to the a wide range of environmental conditions in the subtropical regions that favor the growth of certain microorganisms such as *Aspergillus flavus,* a major producer of aflatoxins (Narasimhulu, 2007). Aflatoxins contamination is a major limitation to the exportation of peanut onto the global market (Emmok, 2010).

The Food and Agriculture Organization estimates that, 25% of the world's food crops production are lost due to aflatoxin contamination, though other approaches to detoxification and to minimize the contaminations are being employed (Proctor *et al*., 2004). Research shows that, the introduction of the new standard by the European Union on the accept/reject aflatoxin contamination levels will cause about 64% (US$ 670 million loss) of peanut coming from Africa on to the world market to be rejected (Otsuki *et al.,* 2001). According to Dhanasekaran & Shanmugapriya., (2011), high levels of consumption of aflatoxin contaminated product have been linked with the incidence of certain cancers that are very deadly in humans. Aflatoxins are noted first class carcinogens in humans (International Agency for Research on Cancer, 2002)

1.1 PROBLEM STATEMENT

Northern Ghana is a leading producer of peanut products such as peanut paste, but almost all peanut paste produced are for domestic use. This may be due to the high risk of microbial contamination through the variable methods of production that lack standard quality supervision. These contaminations can pose serious health problems to consumers. In addition, there is limited data on the effects of peanut processing on the quality of the kernels and its products

1.3 JUSTIFICATION

This research will provide information on proximate, Aflatoxin and microbial levels in the various peanut paste in the study location, which will help in food quality and safety decision-making. Data on proximate composition of these peanut pastes will serve as useful information for consumers.

1.4 MAIN OBJECTIVE

To assess the quality of peanut paste in the three Northern regions of Ghana (Upper East, Upper West and Northern Region)

1.5 SPECIFIC OBJECTIVES

1. To determine the nutrient content of peanut paste sold on Northern sector markets
2. To assess microbial load and aflatoxin levels on the peanut paste sold on Northern sector market

CHAPTER TWO

LITERATURE REVIEW

2.0 PEANUT

Peanuts, originated from South America where they grow very well under subtropical and tropical climatic conditions. The plant grows above the ground but the pods mature in the soil (Martinez, 2014).

Peanuts are a good source of minerals such as calcium, phosphorus, magnesium and potassium and some vitamins such as vitamin E, K and B and contains 44 to 56% oil and 22 to 30% protein on dry matter basis (Keenan & Savage., 1994). It also has high amount of oleic and linoleic fatty acid profile that accounts for about 75 to 80% of the total oil it contains (Nelson *et al.*, 1999). Peanut contains vitamin E, C, B and niacin which can be destroyed during extreme heating, it contains an average of 5 to 7% moisture in freshly harvested peanut and ash of about 3% (Woodroof, 1989). Tocopherol present in peanut oil in an amount of about 0.05 percent is a good sign of the highest stability of the peanut oil (Aoyagi, 2015).

Varieties of peanut which are commonly grown around the world include the Virginia type, the Valencia, the Spanish and the runner and have an average protein content of about 25% (Ahmed & Young., 2011). Different varieties have different protein content and are due to the differences in their gene sequence, geographical location and season of cultivation (Nagaraj, 2009). Peanuts can simply be digested and metabolized by humans (Rena, 2015). The digestibility index for the protein component is 89% which makes peanut highly digestible (Woodroof, 1989). With the several amino acids present in peanut, sixteen of them are responsible for the reaction it undergoes during roasting which leads to browning, due to high amount of sucrose, high temperature of roasting and high fiber content (Woodroof, 1989).

2.1 PEANUT PRODUCTS

Peanuts as a cheap source of protein has aroused research focus in recent times on the utilization of oilseed proteins as edible sources of protein for human and animal consumption. Peanuts have globally been processed for oil and the residual meal is used either as animal feed or as fertilizers

2.1.1 PEANUT BISCUIT

The term biscuit was derived from the Latin word *biscoctus*, meaning twice cooked (Macrae *et al.,* 1993). Biscuits are popular foodstuff, consumed by a large number of populations today, due to their pleasant taste, prolonged shelf life and easy availability at fairly low cost (Gandhi *et al.,* 2001). Biscuits occupy primary position, both for production and consumption as compared to other bakery products (Gandhi *et al.,* 2001).

As biscuits are typically higher in fat content, it becomes difficult to prepare biscuits by reducing fat contents in their formulation to lower the risk of diseases. To reduce the quantity of fat in bakery products fat replacers like peanut paste are used (Sanchez *et al.,* 1995). According to Sadaf *et al.* (2013), although carbohydrate composition decreased significantly in biscuits with the supplementation of peanut paste, There was a significant effect of peanut paste on color of biscuits. They also concluded that, biscuits produced through the incorporation of peanut paste to reduce the quantity of hydrogenated vegetable shortening showed generally acceptable quality characteristics. Hydrogenated vegetable shortening of the biscuits not only increased the protein content but it also reduced the fat contents while imparting better flavor to biscuits.

2.1.2 PEANUT PASTE

Peanut paste is prepared through the dispersion of peanut oil in peanut solids, when roasted peanuts are ground. Peanut paste is has been proven to be a good source of nutrients and low in fat. It is continually applied for the preparation of low calorie improved food products (Woodroof, 1983). Fifty two percent (52 %) of the United States peanut cultivated, are for peanut paste production, and are used as spread or sandwich, 23% are for the production of salted peanut and 21% are used as confectionery (Singh & Singh, 1991). In other countries such as Senegal, Brazil and India, 70 to 100% are crushed or sold out to the world market which are used for the production of oil and feeding animals (Lusas, 1979).

In Ghana, peanut paste can be used as sandwich, condiment or for the preparation of soup or stew (Katz, 2005). Peanut paste is a good source of protein and has a longer shelf life, smoothness and a very pleasant flavor (Chow, 2007). The protein composition (amino acid content) could be compared with other high protein products such as soya beans, bean products and animal products (Ibadullah, 2013). The paste can be processed into different textures such as smooth without any grainy particles, regular and having particle size of less than 0.0625 inch diameter and chunky with particle size of more than 0.0625 (Woodroof, 1989);

Peanut paste contains very important nutrient that are needed by the body for proper development (Ayoola & Adeyeye, 2010). Study by Özcan & Seven, (2007) and Boli *et al*., (2013) shows that, moisture content of peanut paste ranged between 4.50 to 6.06 % . Crude protein with 21% to 35%, crude fat with 24.55% to 50%, ash with 1.86% to 5.5% and crude fiber with 1.00% to 6.78 as shown in Table 2.1.

Table 2.1: Proximate composition of peanut paste

% Moisture	% Crude protein	% Crude fat	%Ash	% Crude fiber
4.50 - 6.06	21- 35	24.55 -50	1.8- 5.5	1.00- 6.78

Source:(Özcan & Seven, 2007)

Peanuts paste contains fat in the form of monounsaturated and polyunsaturated fats and this can lower LDL cholesterol and triglycerides levels by promoting the increase of HDL cholesterol (Kris-Etherton *et al*., 1999). Peanut paste produced from high oleic varieties have higher stability and longer shelf life (Riveros *et al*, 2009). According to Fraser *et al*., (1992), frequent peanut paste consumption can reduce the incident of coronary heart diseases by 25 to 50%.

Consumption of peanut snacks daily is very important to the health of the individual since it contains other nutrient such as calcium, fiber, protein carbohydrate and fat essential to the human systems development (Hu *et al.*, 1998). Peanut paste can therefore serve as a good product for the control of type 2 diabetes (peanut butter is low in Glycemic index and Glycemic load) when consumed frequently or incorporated into our daily servings (Jiang *et al*., 2002). When peanut products is added to meals with high glycemic load, it reduce post prenatal glycaemia (Johnston & Buller, 2005)

2.2 CONSUMPTION RATE OF PEANUT PASTE IN NORTHERN GHANA

Peanut paste is one of the most important peanut product in the world, especially at places where poverty is at the highest peak (Omer *et al*., 2001). Research by Du Toit *et al*., (2008) shows that, median infants living in Israel between the age of 8 to 14

months consume at least 7.1g of peanut protein, which according to Yussif., (2014) represents 8 times of peanut paste in a month. Contrary to this, Infants from the United Kingdom takes it zero times in a month, indicating a low consumption rate in this part of the world compared to Africa (Ghana).

In Ghana, 80% of the population living in the Northern part of Ghana consume peanut and peanut product, and 32% percent take it as many as three times in a week (Yussif, 2014). The intake of peanut and its product such as peanut paste is increasing daily in the Northern part of Ghana (Tsigbey & Braderngurg, 2004). The production and sales of peanut and its product (peanut paste) serves as a major source of livelihood to the women in Northern Ghana (Millar & Yeboah, 2006) where it is publicized on tables for consumers to buy (Plate 2.1).

Plate 2.1: Peanut paste on display at the market

Source: (Author, 2015)

2.3 PRODUCTION OF PEANUT PASTE

The procedure in peanut paste production includes de-shelling of the dry peanut, roasting, cooling, blanching, and removal of foreign particles (including seed coat), grinding, cooling and packaging as shown in figure 2.1. Occasionally, salt and other ingredient such as fat, sugar and other antioxidants are also added to increase the shelf life and improve the quality (Woodroof, 1989). The color of peanut paste could be described as being heavy roasted and some may be light roasted depending on the type

preferred by the consumer, since differences could be seen during frying (Settaluri *et al.,* 2012). Figure 2.1 shows the production of peanut paste from *Nkatesari* as described by Woodroof (1989)

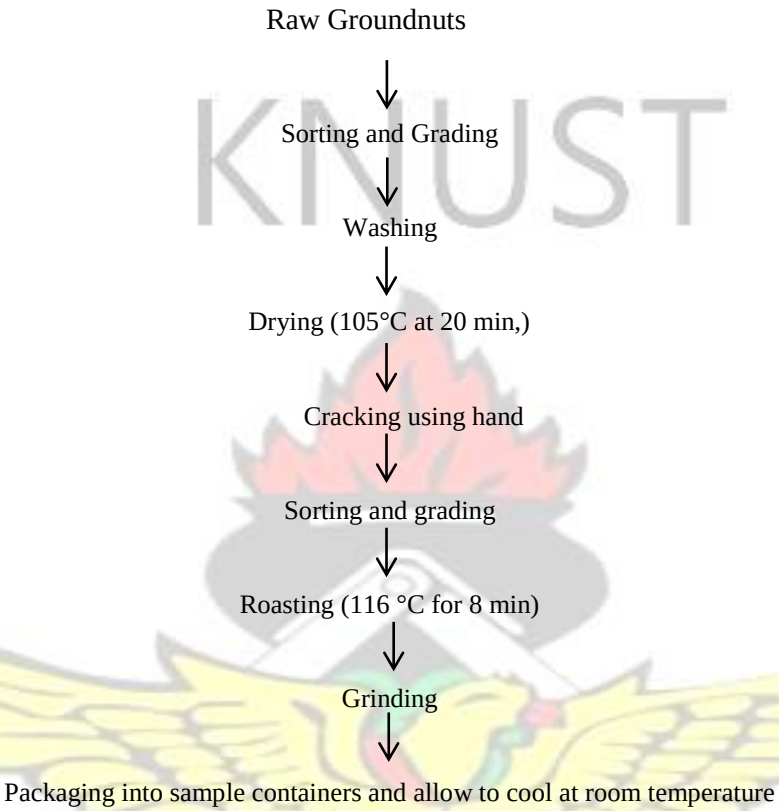


Figure 2.1: Peanut paste production from *Nkate-sari*

2.3 CHALLENGES WITH PEANUT PRODUCTION

2.3.1 MICROBIAL CONTAMINATION OF PEANUT PASTE

Peanuts generally, do not pose a huge risk for food contamination (Engbe, 2007). This largely is due to the roasting step where peanuts are reduced to the 1.25% moisture content and <0.75 water activity (aw) (Engbe, 2007). Moisture is required for most microorganisms to survive. The low aw inhibits growth of most bacteria and many molds. Since peanuts are rarely eaten raw, roasting not only improves peanut aroma, flavor, and texture, but also destroys contaminating microorganisms (Woodroof, 1983). Nonetheless, Very few outbreaks of foodborne with relation to peanuts were likely due

to poor handling practices after a thermal treatment step, particularly roasting (Woodroof, 1983).

From the foodborne diseases perspective, areas of concern for peanuts primarily revolve around from aflatoxin contamination, a toxic metabolite produced by the mold *Aspergillus*, and cross contamination from sources that introduce pathogens to peanuts after processing. Proper peanut processing and handling postharvest should therefore, ensure a safe product for consumers. It is recommended to implement a cleanup protocol using chemicals that are food grade and environmental friendly (Tsitsigiannis *et al*., 2005).

Peanut paste should contain no levels of *Salmonella,* Total plate count should not exceed 10,000 CFU/g, whiles yeast and mould count should be less than 100 CFU/g. *E.coli.* In addition, total coliform should not be more than 10 CFU/g as shown in Table 2.2 (Council, 2009)

Table 2.2: USDA acceptable levels of microbes in peanut paste

Microorganism	Expected levels
Salmonella	Negative
E. coli	<10 CFU/g
Coliform	<10 CFU/g
Aerobic plate count	<10,000CFU/g
Yeast	<100CFU/g
Mould	<100CFU/g

(Council, 2009)

2.3.2 AFLATOXIN CONTAMINATION

Food contamination caused by Aflatoxin could occur at any point along the value chain, it does not only cause post-harvest lost but also responsible for high prevalence of liver diseases such as liver cancer (Bababunmi *et al*., 1978). According to Musingo *et al.*

(1989), contaminations that commonly occur along the value chain can be very resilient during processes such as storage, handling and processing of food and animal feeds.

There are several types of aflatoxin in nature, among these, aflatoxin B1 and B2, G1 and G2 are the common and the most important which caused human disease (Haydes *et al.,* 1991). The mechanism by which aflatoxin B1 can cause disease in humans is by the formation of epoxides when the aflatoxin molecule is activated by the use of cytochrome P450 reductase at the end of the furanos ring which is as a result of the presence of proteins such as DNA, RNA (Wang & Groopman, 1999).

Major symptoms of aflatoxin infection involves immune system suppression and acute liver cirrhosis; since the liver plays a major role in detoxification of metabolites (Beasley, 2011). Also, severe damage and cirrhosis of the liver cells are the major effect of ingesting very high doses of aflatoxin (Wang & Groopman, 1999). According to Dhanasekaran & Shanmugapriya., (2011), high levels of consumption of contaminated product have been linked with the incidence of certain cancers that are very deadly in humans. Aflatoxins are noted first class to cause human cancers
(International Agency for Research on Cancer, 2002)

Humans or animals with low immune system are more susceptible to infection from aflatoxin (Nigam *et al.,* 2009). The coupling effect of some deadly infectious diseases such as hepatitis B/C, TB, HIV and consuming high levels of contaminated food have led to higher mortality among patients whose immune system were down due to aflatoxin infection. Some major symptoms of aflatoxin in poultry includes poor feeding ability, liver cirrhosis, suppression of the immune system and a comparative change in weights and size of organ (McKenzie *et al*., 1997). aflatoxins are often found in high concentrations in cereals, peanut, maize, and other products.

A study on the occurrence of aflatoxin in Chinese peanut paste samples (Table 2.2), revealed that, out of 50 peanut paste samples, 41 tested positive for aflatoxin B1 at a level of 68.51 μg/kg (Li *et al*, 2009). Levels of aflatoxin contamination during peanut paste production as shown in Table 2.3 shows that, roasting at 160°C had 51% reduction, 27% after blanching and an 11% reduction after grinding, however, most of the contamination of peanut paste is after process of production (Siwela, 2011).

Table 2.3: Aflatoxin levels in peanut paste at different treatment point

PROCESS	*% AFB1*	*% AFB2*	*% AFG1*	*% AFG2*	*% TOTAL*
ROASTING	***37***	***79***	***48***	*38*	***51***
BLANCHING	***57***	***19***	***27***	*23*	***27***
GRINDING	***3***	***3***	***6***	*33*	***11***
% TOTAL REDUCTION	***79***	***99***	***81***	*94*	***89***

Source: (Siwela, 2011)

CHAPTER THREE

MATERIALS AND METHODS

3.0 THE MARKET SURVEY

A market survey was conducted in the three Northern regions of Ghana (Northern, Upper West and Upper East). Structured questionnaires were administered to 24 peanut

paste sellers in the sampling zones (Table 3.1) using simple random statistical method (4 from each market and a total of 8 from each Region) to acquire knowledge on the processing methods before buying the peanut paste from them. Quartering sampling method was also used to determine the laboratory samples used for the various laboratory procedures.

Table 3.1: Research study areas

Regions	Sampling zone
Northern	*Aboabo* and *Tamale* central market
Upper West	*Wa* central market and *Gonomuni* market
Upper East	*Navrongo* central market and *Bolgatanga*

3.1 PREPARATION OF PEANUT PASTE CONTROL SAMPLE

3.1.1 SOURCE OF RAW MATERIAL *(NKATE-SARI)*

Nkate-sari was used to produce the control peanut paste sample. *Nkate-sari* is an improved variety of peanut released by the Council for Scientific and Industrial Research of the Savannah Agricultural Research Institute at *Nyankpala* in the Northern region of Ghana. Dried peanut sample (5.0kg) of *Nkate-sari* in storage from the 2014 harvest were obtained from the Savannah Agricultural Research Institute, bagged in a clean jute sack and transported by bus in an ice pack container in an 8h journey to the Kwame Nkrumah University of Science and Technology, Kumasi. Samples were stored under cold condition prior to analysis.

3.1.2 CONTROL SAMPLE PREPARATION OF PEANUT PASTE

Raw peanut samples (2.0kg) were obtained using the quartering sampling protocol. This representative sample was used for peanut paste production. The samples were de-shelled and apportioned into zip lock bags and labeled as shown in plate 3.1, ready for peanut butter production.

Plate 3.1: De-shelled peanut into zip lock bag

Source: (Author, 2015)

3.1.3 PEANUT BUTTER PRODUCTION

Raw peanut samples were sorted and graded before immersion in clean water and washed thoroughly and sun dried. They were then de-shelled, sorted/graded again manually, and 50 g roasted in a clean frying pan at 116°C for 20 min. Roasted samples were allowed to cool at room temperature, then grinded using the attrition mill machine. The milled samples were immediately packaged into zip lock bags and allowed to cool (Junior *et al*., 2014).

3.2 EXPERIMENTAL ANALYSIS

3.2.1 PROXIMATE ANALYSIS

The moisture, crude protein, crude fat, crude fiber, Carbohydrate and ash contents of the peanut butters were determined using standard methods (AOAC, 2003).

3.2.2 MOISTURE DETERMINATION ON PEANUT BUTTER (AOAC, 2003)

Peanut paste (2g) was accurately weighed in a clean, dried petri dish of a known weight (W1). It was quickly placed in a conventional oven at 105 °C for 6 h. The petri dish was then placed in a desiccator for 30 min to cool. After cooling, it was weighed again (W2). The percent moisture was then calculated.

3.2.3 CRUDE PROTEIN DETERMINATION (AOAC, 2003)

Peanut paste (2g) was weighed into a digestion tube, 5 grams of catalyst and 1 glass bead together with 10 mL concentrated sulfuric acid was also added. Digestion tubes were placed in the digester. Digestion commenced initially at low temperature to prevent frothing and boiling at a temperature of 320°C until the solution was clear which is an indicator of complete oxidation. Erlenmeyer flask (250mL) containing 50 mL of 4% boric acid with indicator was placed in a distillation unit and distillation commenced for 10 min whiles the tip of the condenser extended below the surface of the acid solution. 100 mL of water and 70 mL of 50% sodium hydroxide (excess) was added to the digests during the distillation process to ensure complete release of ammonia. 150 mL of distillate was obtained when condenser with ice cold water was used to effectively capture all distilled ammonia and the receiver flask was lowered to ensure that the delivery tube was properly placed for continues distillation. The delivery tube was rinsed with water and the washing was made to drain into the flask.

Titration of the distillate was done with a standardized 0.1 N hydrochloric acid until the first appearance of the pink colour was obtained. Result was recorded to the nearest 0.05 mL volume and calculated.

3.2.4 CRUDE FIBER (AOAC, 2003)

Peanut paste (5g) was taken from the zip lock bags and defatted using the AOAC 2003 standard before subjecting to analysis. 2g of peanut samples were weighted into a flat bottom flask and 200 mL of boiling sulphuric acid (1.25%) was added for 30 min. The resulting solution was filtered through cheesecloth using a funnel and then washed with hot water until it was free from the acid. The residue on the cloth was transferred into a flask and 200 mL of boiling sodium hydroxide solution (1.25%) was added. The flask was immediately connected to the digestion apparatus and boiled for 30 min. The flask was then removed and immediately the solution was filtered and washed thoroughly with boiling distilled water until washing was no longer basic. The residue was rinsed with 15 ml of alcohol. It was transferred into porcelain crucibles and dried at 105°C in an oven for 24 h. It was cooled to room temperature in a desiccator and weighed. The crucible and its weight was incinerated in a muffle furnace at 550 °C. It was cooled to room temperature in a desiccator and weighed. The difference between the two weights was recorded and the percentage crude fiber calculated.

3.2.5 CRUDE FAT DETERMINATION (AOAC, 2003)

Approximately 1 g of dried samples from the moisture analysis was weighed and wrapped in a filter paper and placed in a fat free thimble and then placed into the extraction tube. Clean and dried receiving beaker was weighed and filled to about three quarter with petroleum ether and then fitted into the Soxhlet apparatus. The tap was turned on to allow the flow of water, and heater was also turned on to start the extraction process. After 6h, siphoning allowed ether to evaporate and condense back into the receiving beaker and the process was repeated until extraction was complete. The beaker was disconnected before the last siphoning. Extract was placed in a water bath for the remaining ether to evaporate; the dish was then placed in an oven at

105^{o}C for 2 hours and cooled in a desiccator. The percent crude fat was determined.

3.2.6 ASHING (AOAC, 2003)

Clean empty crucible was placed in a muffle furnace at 600 °C for an hour, it was cooled in a desiccator and then weighed and weight noted W. 1g of sample was weighed and transferred into the crucible and noted W2. The sample was ignited over a burner with the help of blowpipe, until charred. Then the crucible was placed in a muffle furnace at 600°C for 6 h for complete oxidation of all organic matter in the sample. After the process, Crucible was cooled in the desiccator and the weight was noted W3. Percent crude ash was calculated and recorded.

3.2.7 TOTAL CARBOHYDRATE (AOAC, 2003)

Total carbohydrate was determined by difference between 100% and the sum total of determined proximate component

3.3 MICROBIAL LOAD

3.3.1 EQUIPMENT AND MATERIALS STERILIZATION

Sterilization of equipment was carried out before and after the analysis to prevent cross contamination of samples and equipment. Laboratory glass wares were washed and rinsed very well with soap and under running tap water, air dried and kept in an oven for 3h at 160 °C to ensure glassware are clean. Media was prepared under safety condition (fume hood). Loops and forceps for inoculation were flamed to ensure sterility before and after each use. Naked flame was turned on to ensure sterilization of the working environment and 70% alcohol was also used to clean the working bench before and after use (Cheesbrough, 2006).

3.3.2 SAMPLE PREPARATION

Peanut paste (10g) was weighed using a sterile weighing dish and transferred into sterile sample bottles containing 90ml (0.1%) peptone water. Sample was vortexed for about 1 minute at moderate speed. This serves as the initial dilution from which other dilutions to the sixth power was prepared. This dilution was then used for subsequent analysis (Cheesbrough, 2006).

3.3.3 TOTAL AEROBIC COUNT

Plate count agar was used to determine the total aerobics present in the peanut paste samples. Preparation of the plate count agar was done as described by Cheesbrough (2006). After the preparations, 100µL of the serial diluted samples were then plated using the spread plate method and the inoculated plates were then incubated at 37 °C for 24h. Plates that showed visible colonies between 30 and 300 were identified and manually counted. The numbers of colony forming units per gram of samples were calculated by multiplying the number of organisms by the dilution factor (Cheesbrough, 2006)

3.3.4 TOTAL COLIFORMS

The media used was the Violet Red Bile Lactose (VRBL) agar. This media was chosen because of its good selective ability. The Spread plating procedure was used for the inoculation in which 100µL of the serial diluted samples were plated and incubated for 24 hours at 37°C (Cheesbrough, 2006).

3.3.5 FUNGAL ENUMERATION

Malt extract agar was used to determine the presence and the numbers of yeast and molds in the peanut paste samples. Spread plating method was employed with a volume

of 1ml of the serial diluted peanut paste samples and incubated at 27°C for 5 days (Cheesbrough, 2006).

3.3.6 MOULD IDENTIFICATION

Mould cultures were prepared by lifting the mycelia mat of the organism with a sterile inoculation pin into a drop of water on a slide (spreading the mat). It was then covered with a cover slip and observed under a microscope. Different characteristic features of the isolated organism were observed and used in their identification (Cheesbrough, 2006).

3.4 AFLATOXIN DETERMINATION (AOAC, 2008)

Peanut paste (25g) and 5g of sodium chloride were properly blended in a laboratory blender for 2 min to obtain smooth and a homogenous mixture-using pause blending to prevent overheating. The blended mixture was passed through a pre-folded filter paper (Vicam fluttered) to obtain a clear filtrate. 15 ml of the filtrate was pipetted into 125 mL glass stopper Erlenmeyer flask and 30 mL of distilled water added. The flask was closed using the stopper and mixed very well. The diluted filtrate was again passed through a micro glass fiber filter paper for about 30 min to obtain a final and clear filtrate. The filtrate was then passed through affinity column called the AflaTest (Plate 3.2) which contained monoclonal antibody that are specific to aflatoxin B1, B2, G1 and G2. aflatoxins were isolated, purified, and concentrated on the column using 70% CH_3OH. 0.1ml of clear filtrate were then injected into the HPLC (*Cecil* HPLC) through the chamber and were quantified by florescence measurement after reaction with bromine solution as shown in plate 3.2. Individual and total aflatoxins were quantified and recorded on the monitor. The HPLC has a column temperature of 40 degrees, mobile phase consist of 40% methanol, 60% water, 120mg of potassium

bromide and 350micrograms of nitric acid prepared in one liter. Column flow rate was 1ml/min, excitation and emission wavelengths were 360 and 435nm respectively, whiles column types used was C18 (150mm/4.6mm/5micrometers). Limit of detection and quantification were 0.5nanogram/gram and 1nanogram/gram respectively

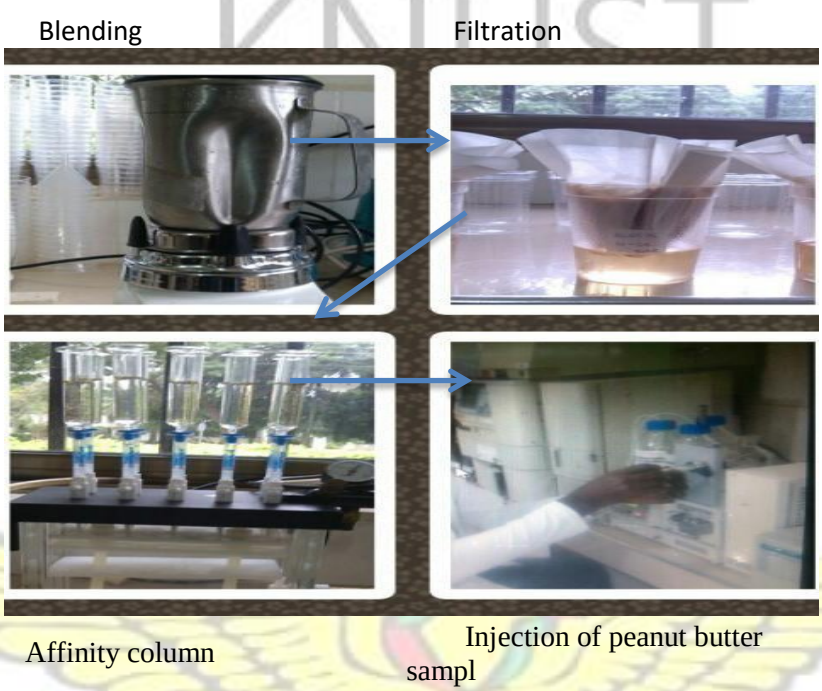


Plate 3.2: Aflatoxin Analysis Procedure

Source: (Author, 2015)

3.5 STATISTICAL ANALYSIS

Statistical Package for Social Science (SPSS version 20.0) was used for Statistical analysis. Analysis of variance (one way ANOVA) was used to determine whether the values recorded on the various markets show any significant difference and one sample t-test was used to compare variations between values recorded and standard values.

CHAPTER FOUR

RESULTS AND DISCUSIONS

4.0 SURVEY RESULTS

The survey revealed, seventy five percent (75%) of peanut past producers in the study were between the ages of 31 to 35 years and 25% between the ages of 20 to 25. All the sellers interviewed, were females (Table 4.1) suggesting that, the peanut business in the Northern parts of Ghana maybe considered, a female dominated activity with production skills being passed down from mother to daughters. Although four percent (4%) of the respondents acquired raw materials from their own harvest, approximately ninety six percent (96%) of the peanut paste sellers acquired their raw materials from the market already de-shelled, implying that peanuts may have already been exposed to contamination even before processing. All the respondents were however, ignorant of the peanut varieties they bought, an indication that there may be variation with respect to organoleptic quality.

Table 4.1: Survey results obtained from the various peanut past producers

		Frequency	Percentage
Type of Mills	Commercial	24	100.0
Sex/Gender	Female	24	100.0
Age (years)	20 - 25	6	25.0
	31 - 35	18	75.0
Education	No Formal Education	24	100.0
Acquisition of Skills	From Parent	24	100.0
Source of Peanut	Own Farm	1	4.2
	Market	23	95.8
Source of Water	Pipe	2	8.3
	Stream	18	75.0
	Borehole	4	16.7
Transportation	Bicycle	3	12.5
	Donkey	3	12.5
	Head	18	75.0
Sorting	No	24	100.0
Shelflife	4 weeks and above	24	100.0

There was no sorting, grading or blanching before during processing, since this will increase production cost. Seventy five percent (75%) used water from the stream to wash their utensils during production, whiles 16.7% and 8.3% used borehole and pipe

water respectively. According to the respondents, every organism present in the water will be killed during processing. All producers in these markets used commercial mills to mill their products, since it is expensive to acquire a private mill. None of them added any other ingredient during milling but water was added during milling to help remove left overs of the paste from the mill. According to the sellers, the mills were not cleaned between processing or batches. None of these producers had formal education of any kind but had some knowledge on safety and hygiene. Seventy five percent (75%) of the producers transport their product to the market on head, 12.5% by donkey and 12.5% by bicycle respectively, this serves as their means of transport.

All the sellers packaged their product in plastic containers for display at the market. This packaging method serves as means of advertisement.

4.1 PROXIMATE COMPOSITION

4.1.1 MOISTURE

The proximate compositions of the different peanut samples are presented on Table 4.2. The percentage moisture of the peanut paste samples generally ranged from 5.05 ±0.07 to 6.45 ±0.21. This was similar to previous studies conducted by Özcan and Seven (2007), who reported values of 4.5 to 6.06 ±0.18. These values however contrasts reports made by Chang *et al.* (2013) who reported a value of 1%. The contrast may be attributed to the varieties used as the starting material for the peanut paste production, since different peanut varieties have different compositions of moisture (Payman *et al*., 2011). Statistically, peanut paste samples from all the sampling zones in this study, significantly varied from each other ($p>0.05$) except samples from *Navrongo* central market and the *Wa* central market that showed no significant difference. The variation, in addition to diversity in raw material variety may also have resulted from the consistent addition of water during processing (milling) to aid in the removal of the

residue of samples from the mill. Peanut paste samples from *Bolgatanga* central market with a moisture content of 5.05 ±0.07 may have a longer shelf-life, due to its comparatively lower moisture content, which implies less water for microbial activities and hence delay in food spoilage (Copetti *et al*., 2011).

Table 4.2: Proximate composition of peanut paste samples

MARKETS	% MOISTURE	% CRUDE PROTEIN	% CRUDE FAT	% CRUDE FIBRE	% ASH	% TOTAL CARBOHYDRTES
TcM	5.90±0.28^{b}	23.67±0.05^{a}	39.10±0.76^{a}	1.65±0.02^{a}	2.67±0.47^{a}	27.03±0.60^{a}
TaM	5.25±0.21^{b}	30.73±5.25^{a}	31.86±2.50^{b}	1.42±0.01^{a}	3.10±0.01^{a}	27.65±0.96^{a}
WcM	6.45±0.21^{a}	31.56±0.78^{a}	38.22±0.32^{a}	1.13±0.01^{b}	3.21±0.28^{a}	19.44±0.19^{a}
WgM	5.85±0.21^{b}	30.99±0.18^{a}	39.52±0.26^{a}	1.09±0.01^{a}	2.66±0.62^{a}	19.90±0.77^{a}
BcM	5.05±0.07^{b}	28.67±0.06^{a}	36.68±0.05^{a}	1.57±0.08^{b}	2.25±0.12^{a}	25.80±0.26^{a}
NcM	6.25±0.07^{a}	26.16±1.15^{a}	37.22±0.16^{a}	1.89±0.01^{c}	2.94±0.09^{a}	25.55±0.27^{a}
Control	5.45±0.35^{b}	26.48±0.12^{a}	38.91±0.01^{a}	1.27±0.01^{d}	2.34±0.30^{a}	25.57±0.18^{a}

Key: TcM: Tamale central market, TaM: Tamale Aboabu Market,WcM: Wa central market,WgM: Wa Gonomuni Market, BcM: Bolga central Market, NcM: Navrongo central Market,Control (Peanut paste from *Nkate-sari*). Values are means ± standard deviation. Different Superscripts imply significant difference at $p<0.05$

4.1.2 CRUDE PROTEIN

Protein content was highest in peanut paste bought from *Wa* central market with a value of 31.56±0.78 and the least protein content from the *Tamale* central market samples with a value of 23.67±0.05. This may imply that, peanut varieties used in the production of peanut paste samples in *Wa* central market maybe a better protein compliment that can be used to address protein deficiencies in that region. All the samples however showed no significant difference ($p<0.05$). In addition, the samples did not significantly vary from the control samples.

Protein content ranging from 23.67±0.05 to 31.56% ±0.78 shows that, protein values falls within studies conducted by Boli *et al*., (2013) who reported values from 21 to 35% although differences in protein content may arise from differences in varieties used in these areas or as a result of milling high protein foods such as fish or soybean product

before milling the peanut. People who require high protein may therefore use peanut paste to compliment the inadequate proteins in their foods. Proteins available to the body are used for the development of worn out tissues and body building mechanism (FAO/WHO/UNU, 2007)

4.1.3 FAT

Percentage crude fat values ranged from 31.86±0.76 in the *Tamale* central market (TcM) to 39.59±0.26 in the *Wa gonomuni* market (WgM), against the control (paste from *Nkate-sari*) with a value of 38.91±0.01 (Table 4.2).

Although there were variations in the results from the different locations ranging from 31.86 ±2.50 to 39.72 ±0.26, only fat values of the *Tamale aboabu* market samples showed significant difference ($p<0.05$) among the rest of the market samples, including the control (butter from *Nkate-sari*). It was observed that, peanut paste bought from the markets and the control were within the ranges of 24.55 to 50% as reported by Özcan & Seven (2007).

The differences in some of the fat results obtained in the peanut paste samples may be due to the varieties used (Dwivedi *et al.,* 1993). It can therefore be recommended to patients of higher energy requirement to use peanut paste from these sectors, since they contain appreciable amount of fat. According to Vanessa., (2011), peanut fat contains 9 kCal of energy per gram of fat and carbohydrate has 4 kCal per gram carbohydrate.

4.1.4 FIBER

Percentage crude fiber content of the peanut paste samples shows least values between 1.09 ±0.01 from *Wa gonomuni* market and highest values of 1.89 ±0.03 from the *Navrongo* central market (NcM) samples. *Tamale* central market (TcM) samples had the second highest fiber content of 1.65 ±0.02. Statistical analysis showed no significant

difference ($p>0.05$) within the *Tamale aboabu* market (TaM) samples, *Tamale* central market (TcM) and *Wa gonumuni* market (WgM) samples. Also there were no significant difference ($p>0.05$) between the *Wa* central market samples and the *Bolga* central market samples but shows a significant difference ($p<0.05$) between the control and the *Navrongo* central market samples respectively, as shown in Table 4.2.

The percentage crude fiber content of the samples obtained was relatively lower in comparison with previous studies by Özcan & Seven., (2007), who reported values of 1.00 to 6.75% but was similar to that of the control sample. Though the fiber contents of the samples varied from market to market, higher fiber values were obtained for some of the peanut paste samples as shown in Table 4.2. Thus, peanut paste from these markets may serve to contribute fiber to patients with fiber requirment (Boli *et al*., 2013)

4.1.5 ASH

Percentage crude ash was determined; the analyzed data revealed that, *Wa* central market (WcM) peanut paste had the highest ash content with 3.21% ±0.28. The values recorded generally agreed with those reported by Özcan & Seven, (2007), who recorded values of 1.86 to 5.5% Despite the fact that there were variation between peanut paste samples bought from the various markets and the control (butter from *Nkate-sari*), statistical analysis showed no significant difference ($p >0.05$). The variations in ash values may have resulted from the wearing of the attrition mill during milling of peanut.

High ash content in food is an indication of high minerals content, although it may also be an indication of impurities in the samples (Ayoola *et al*., 2012).

4.1.6 CARBOHYDRATE

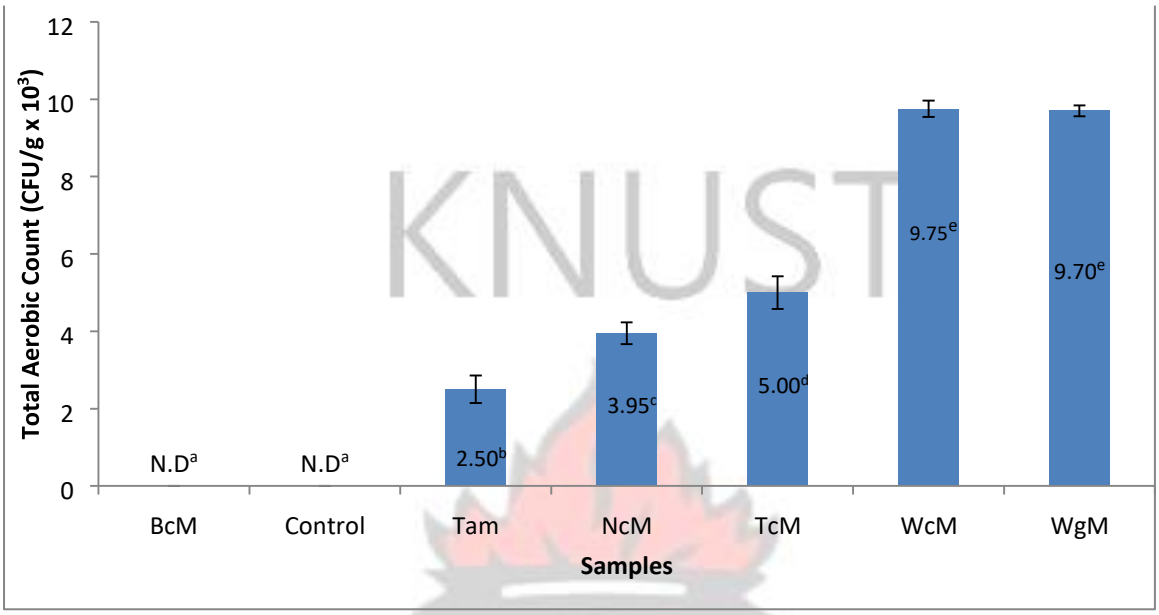
Carbohydrate content in the *Tamale Abuabo* (TaM) samples was higher than the rest of the samples with a value of 27.65±0.96. Despite the fact that there were variations in the carbohydrate values recorded in the samples as shown in table 4.2, statistical analysis shows no significant difference ($p>0.05$). Carbohydrate content in some of the samples were found to be higher than previous studies of 15 to 26% (Boli *et al*., 2013). Low carbohydrate content may be due to the variety of raw peanut used for the paste preparation (Asibuo *et al*., 2008). Peanut paste from these markets can be a good source of carbohydrate for malnourished children, since carbohydrate is needed by the body for proper cellular activity (Kunemund, 1988).

4.2 MICROBIAL LOAD

4.2.1 TOTAL AEROBIC COUNT

From Figure 4.1, *Wa Gonomuni* market (WgM) samples had the highest contamination of 9.7×10^3 cfu/g, compared to Samples from the *Tamale Aboabu* market (TaM) that had the lowest contamination level of 2.5×10^3 cfu/g. All the samples were however, below the maximum acceptable limit of 10^4 (Council, 2009). *Bolga* central market (BcM) samples and the control had no count. The absence of these microbes in the *Bolga* central market suggests that the processing method, used by the producers in that market was effective in the control of these microbes. In addition *Wa* central market (WcM) and *Wa gonomuni* market samples significantly varied ($p>0.05$) from the *Bolga* central market (BcM), *Tamale Aboabu* market (TaM), *Navrongo* central market (NcM), and *Tamale* central market (TcM) samples. This difference may be attributed to the

difference in processing environments and conditions of processing as revealed in the survey.



Key: TcM: Tamale central market, TaM: Tamale Aboabu Market,WcM: Wa central market,WgM: Wa Gonomuni Markt, BcM: Bolga central Market, NcM: Navrongo central Market, N.D: Non -detectable. Different Superscripts imply significant difference at $p<0.05$

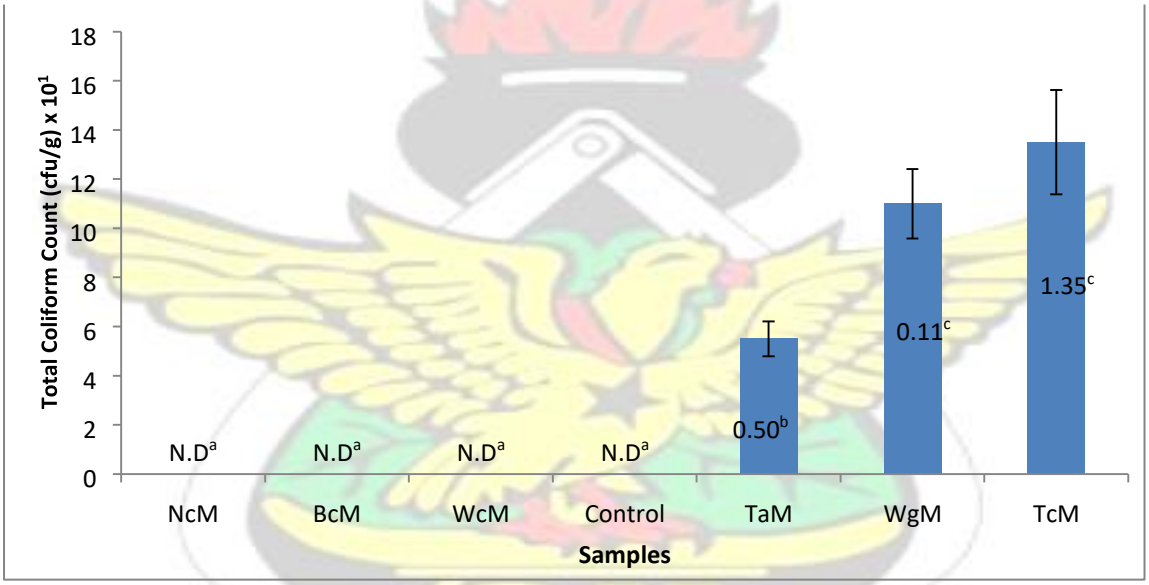
Figure 4.1: Total aerobic counts after 48 hours incubation

Lack of Good Manufacturing Practices (GMP) such as the addition of stream water during processing may provide a favorable medium for microbial proliferation (Copetti *et al*., 2011): the stream water used to wash the utensils during processing by some of the producers may serve as a vehicle of contamination into the final product. Also already de-shelled raw peanut, purchased from the market, may have already been exposed to contamination that can survive the processing treatments (Copetti *et al*., 2011).

4.2.2 TOTAL COLIFORMS

From figure 4.2, there were no coliforms detected in *Bolga* central market (BcM), *Navrongo* central market (NcM), *Wa* central market (WcM) and the control (butter from *Nkate-sari*) samples. Although *Tamale* central market (TcM) samples had counts of

1.3×10^1, which is above the maximum acceptable limit of 10^1 cfu/g (Council, 2009), *Tamale Aboabo* market (TaM) and *Wa gonomuni* market (WgM) reported low counts below this limit. This was in agreement with Chang *et al.* (2013) who also reported presence of coliforms in peanut butter samples but below the maximum acceptable limit. Statistical analysis showed significant differences ($p<0.05$) between the *Tamale aboabu* market samples and the *Wa gonomuni* market samples, in contrast with samples from the *Navrongo* central market (NcM), Bolga central market (BcM), *Wa* central market (WcM) and the control (paste from *Nkatesari*), which had no significant differences ($p>0.05$).



Key: TcM: Tamale central market, TaM: Tamale Aboabu Market,WcM: Wa central market,WgM: Wa Gonomuni Market, BcM: Bolga central Market, NcM: Navrongo central Market, N.D: Non- detected. Different Superscripts imply significant difference at $p<0.05$

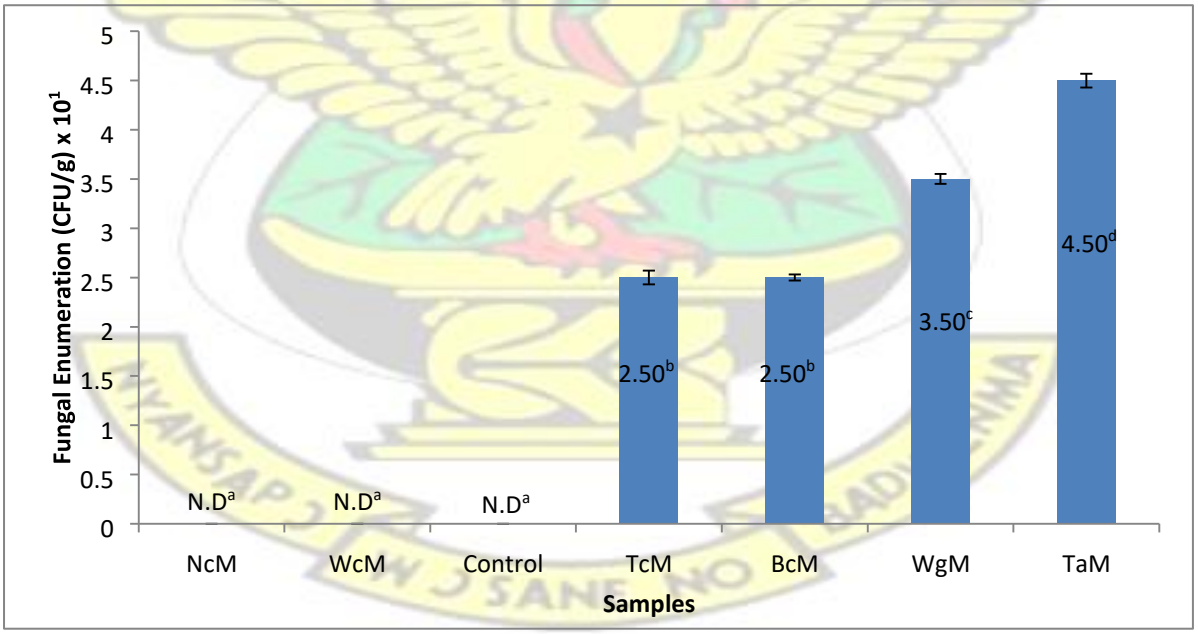
Figure 4.2: Total coliform count after 48 hours of incubation

The differences may be attributed to variations in hygienic conditions, as total coliform counts in food samples are indications of poor hygienic practices during and after production on the part of the producer (Reij & Den Aantrekker, 2004). According to the United States Drug Administration indicated that, total coliform levels above 10 cfu/g may be a sign of high contamination which could lead to diarrhea and other

foodborne diseases (Council, 2009). The presence of coliform in the peanut paste samples may be an indication of fecal contamination, which may also have resulted from direct contact of the product with fecal matter, through packaging to storage and sale at retailed markets since most of the coliforms are likely to have been killed during processing (Smith & Stratton, 2007).

4.2.3 FUNGAL ENUMERATION

There was no fungal contamination in the *Navrongo* and the control samples. Even though the remaining samples showed contaminations, they were all below the United States Drug Administration (USDA) acceptable standard of 100cfu/g (Council, 2009). Statistical analysis showed no significant difference ($p>0.05$) between the NcM, WcM, the control, TcM and the BcM samples although there was significant differences ($p<0.05$) between the WgM samples and the TaM samples as shown in figure 4.3



Key: TcM: Tamale central market, TaM: Tamale Aboabu Market,WcM: Wa central market,WgM: Wa Gonomuni Market, BcM: Bolga central Market, NcM: Navrongo central Market, N.D: Non -detected. Different Superscripts imply significant difference at $p<0.05$

Figure 4.3: Fungal enumeration of peanut paste samples.

Lack of hazard analysis and critical control points (HACCP) programs, coupled with inadequate understanding on Good Manufacturing Practices can lead to yeast and moulds contaminations in food (Odu & Okonko, 2012). The mould contaminations observed in some of the samples may have resulted from poor milling conditions, using contaminated raw materials, lack of formal education, inadequate knowledge on Good Manufacturing Practice and the use of stream water to wash utensils as reported in the survey results.

4.2.3.1 **MOULD IDENTIFICATION**

Blastomyces Dermatitidis was identified in the peanut paste sample from Bolga central market samples. *Aspergillus parasiticus* was also identified in samples from Tamale central market, *Wa* central market and *Wa Gonomuni* market samples respectively as presented in Table 4.3. However, the control, *Tamale* central market (TcM), *Navrongo* central market (NcM) samples showed no contamination.

Table 4.3: Mould identified in peanut paste samples from selected markets

ORGANISMS ISOLATED	WgM	BcM	TaM	WcM	TcM	NcM	CONTROL
Aspergilus parasiticus	+	-	+	+	-	-	-
Blastomyces Dermatitidis	-	+	-	-	-	-	-

TcM: Tamale central market, TaM: Tamale Aboabu Market,WcM: Wa central market,WgM: Wa Gonomuni Market, BcM: Bolga central Market, NcM: Navrongo central Market, Control (paste from *Nkate-sari)*

Blastomyces is a disease caused by fungus known as *Blastomyces Dermatitidis* (Chapman, 2008). This disease results in chronic to acute respiratory tract infection which usually occurs in people with low immune system (HIV infected patients) and people with organ transplants (Chapman, 2008). *Blastomyces Dermatitidis* may contaminate food products during processing, packaging and marketing (Chapman,

2008) when they are exposed to fungi. In plate 4.1, a market seller openly advertises her product to buyers while ignorantly exposing the peanut paste to microbial contamination.

This may be attributed to inadequate knowledge of the basic good food safety principles which may bring about cross contamination during such exposure.

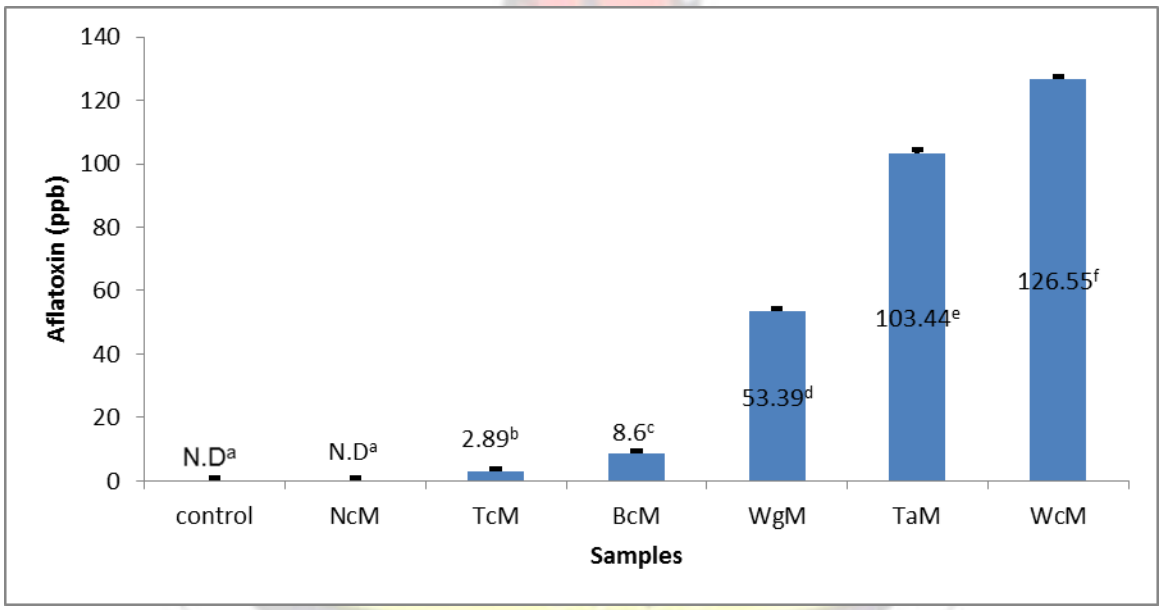
Plate 4.1: Peanut paste on display at the Bolgatanga central market

Source (Author, 2015)

4.3 AFLATOXIN

Figure 4.4 presents aflatoxin contamination levels of all the peanut butter samples. Peanut paste samples from the Control, *Navrongo* central market (NcM), and *Tamale aboabu* market (TaM) showed aflatoxin contamination of 0 ppb, 0 ppb and 2.89 ppb respectively which was below the Codex acceptable limit of 20 ppb. Although *Bolgantaga* central market (BcM) samples were below the Codex acceptable limit of 20 ppb (Nigam *et al.*, 2009), it risked being rejected by the European Union as it

exceeded their maximum acceptable limit of 4ppb (Holbrook *et al.*, 2008). All the samples, from the remaining markets were highly contaminated as they all exceed (Figure 4.4) the maximum acceptable limit of both the United States and European Union. The contamination was statistically significant ($p<0.05$), in comparison with the non-contaminated samples. The results of the aflatoxin study was in agreement with those reported by Siwela (2011): 51 ppb, 27 ppb, 99 ppb, 79 ppb, 3 ppb and 6 ppb. According to their report, the aflatoxin concentrations maybe mitigated by roasting and blanching.



Key: TcM: Tamale central market, TaM: Tamale Aboabu Market,WcM: Wa central market,WgM: Wa Gonomuni Market, BcM: Bolga central Market, NcM: Navrongo central Market, N.D: Non- detected
Different Superscripts imply significant difference at $p<0.05$

Figure 4.4: Aflatoxin contamination levels in peanut paste from the various markets

High aflatoxin contaminations from some of the markets may be attributed to the use of aflatoxin-contaminated raw materials and poor packaging and storage as suggested by Ndung et *al.* (2013). This contamination may have come from the field during production or during storage by the peanut paste producers (Dorner & Cole, 2002). It was observed that, none of the producers from the markets wash their raw materials or

sorted low-grade peanuts, before processing. Contamination of peanut by *Aspergilus flavus and Aspergilus parasiticus* during peanut processing maybe through improper handling, cross contamination, use of contaminated utensils and packaging (Diedhiou *et al*., 2012)

It was reported that, people living in rural areas of some West African countries are highly exposed to appreciable levels of aflatoxin contamination through their daily meals (Egal *et al*., 2005). This puts them at risk of contracting diseases like cancer and other cardiovascular disease (Egal *et al*., 2005). Severe damage and cirrhosis of the liver cells are some other effect of ingesting very high doses of aflatoxin (Wang & Groopman, 1999). High levels of consumption of aflatoxin contaminated products have been linked with the incidence of certain cancers that are very deadly to humans (Dhanasekaran & Shanmugapriya, 2011). Major symptoms of aflatoxin health effect involve immune system suppression and acute liver cirrhosis, (Beasley, 2011). Also, aflatoxins are categorized as first class carcinogenic (International Agency for Research on Cancer, 2002). aflatoxin exposure in people living with infectious diseases such as hepatitis B/C, TB and HIV have led to high mortality rates as a result of weakened immune systems (Turner *et al*.,2003). High temperatures during storage of samples have also been noted to favor the growth of these fungi, and this is an indication of improper storage of raw materials and the product (Lansden & Davidson, 1983).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.0 CONCLUSION

Producers of peanut paste in selected sampling zones of this study lack Good Manufacturing Practices and a well-defined HACCP programs even though peanut paste has economic value and health benefits to these inhabitants. Peanut paste from these markets (TcM, TaM, WcM, WgM, BcM, NcM) and the control (paste from *Nkate-sari*) were found to have relatively high fat, protein and ash content compared to other studies.

Peanut paste samples from the selected areas showed some level of microbial contamination, levels of contaminations are still within USDA acceptable standard. Some of the peanut paste samples were however found to be unsafe, they contained harmful moulds: *Aspergilus parasiticus Blastomyces Dermatitidis*. Peanut paste samples from *Wa guomani* market, *Tamale Aboabo* market and *Wa* central market were also found to contain aflatoxin, which are known to have serious health implications upon exposure. There is the need for training programs for those in this sector to build their capacity in food safety practices such as good manufacturing practice and HACCP.

5.1 RECOMMENDATIONS

The varieties of peanuts used by the various producers should be investigated. Further research should also be conducted on the different production methods in the various research locations. Raw peanut samples from the producers may also be analyzed to determine the base line contamination.

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APPENDICE

APPENDIX 1 QUESTIONNAIRE

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF SCIENCE

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

QUESTIONNAIRE ON EVALUATION OF PEANUT PAST IN SELECTED MARKETS IN NORTNERN GHANA

I am a student of KNUST conducting a research on the evaluation of peanut paste in the three Northern Ghana (Northern, Upper west, Upper East) to ascertain the safety of the product on local markets. Information received will be treated confidentially and used for academic purpose only

(PEANUT PASTES SELLERS)

1. Location (market)……
2. Name of sample: ……
3. Sex of the peanut past seller
   a. Male [ ] b. Female [ ]
4. Age
   a. 20- 25 years [ ] b. 25-30 years [ ] c. 30-35 years [ ] d. 35 years and above [ ]
5. 2. Level of education
   a. JHS [ ] b) SHS [ ] c) Tertiary [ ] d) Nil [ ]

6. 3. Area of residence …….

7. Source of water

   a. Pipe [ ] b) bore hole [ ] c) river [ ] d) stream [ ]

Production period

8. How long can the product stay without going bad?

   a. 1-7 days [ ] b. 1-2 wks [ ] c. 3-4 wks [ ] d. above 4 wks [ ] e. I can't remember [ ]

Production process

9. How did you learn the method of production?

   a. Formal education [ ] b. Apprentice [ ] c. From parent observation [ ]

10. Where did you acquire your raw peanut?

   a. Own harvest [ ] b. Market [ ] c. Research institution

11. If from own harvest was it from

   a. Storage [ ] b. Freshly harvested [ ]

12. How long had it been stored?

   a.1mth [ ] b.2mths [ ] c.3mths [ ] d. more than 3 mths [ ]

13. Do you know the variety you use frequently?

   a. Yes [ ] b. No [ ]

14. If yes what is the name of the variety? .....

15. Do you sort or grade your peanut before cracking?

   a. Yes [ ] b. 2 No [ ] c.

16. Do you wash the peanut before or after cracking?

   a. Yes [ ] b. No [ ]

17. Do you sort or grade after cracking?

a. Yes [ ] b. No [ ]

18.How do you clean your utensils before using them?

a. Soap and clean tape water [ ] b. disinfectant and water [ ] c. I do not clean [ ]

19. How long after frying before you mill?

a.30 minutes [ ] b. after one hour [ ] c. 24 hours [ ] d. months [ ]

20. What type of mill do you use?

a.Commercial mills [ ] b. Personal mill [ ] c. 24 hours [ ] d. months [ ]

21. Do you clean your mills?

a.Yes [ ] b.No [ ] 22. If yes how?.....

23. Apart from the peanut do you add any other ingredient during milling? a.Yes [ ] b.No [ ]

24. If yes what are they?…….

25. How do you package the butter to the market after milling?.....

26. How do you transport it to the market?

a. By carrying on the head [ ] b. on motor bike [ ] c. Bicycle [ ] d. car [ ] e. Donkey [ ]

Comment

27. Have you any idea why you should produce the product under hygienic conditions?

a. Yes [ ] b. No [ ]

28. If yes why?.....

29. Will your customers prefer a quality product at a higher cost?

a.Yes [ ] b. No [ ]

30. Can you differentiate between good paste and bad paste?

a.Yes [ ] b No [ ]

31. What are the signs (characteristics) of a bad peanut paste?

APPENDIX 2: FORMULAS USED IN CALCULATION

FORMULA USED IN MOISTURE CALCULATION

$$\% \text{ moisture} = \frac{W1 - W2 \times 100}{\text{Weight of sample}}$$

W1 = Initial weight of crucible + Sample

W2 = Final weight of crucible + Sample

Note: Moisture free samples were used for further Analysis

(AOAC, 2003)

FORMULA USED FOR THE CALCULATION OF PERCENTAGE CRUDE PROTEIN

$$\% N = \frac{1.4007 * c * (V - Vb)}{\text{Sample weight (g)}}$$

c: Concentration of the standard-acid solution: Hydrochloric acid 0.1N or c = 0.1 mol/l

Alternative: sulfuric acid 0.1N or c = 0.05 mol/l

V: Consumption of the standard acid in ml (Sample)

Vb: Consumption of the standard acid in ml (Blank Sample)

Protein (g per 100g) = % total nitrogen x appropriate nitrogen conversion Factor (6.25) and results was reported in gram per 100 g of sample and to one decimal place.

(AOAC, 2003)

FORMULA USED FOR THE CALCULATION OF PERCENTAGE CRUDE FIBER

% CRUDE FIBER BY WEIGHT= $\frac{W1 - W2}{W}$

Where W1 and W2 are the initial and final weight of the crucible and crucible plus samples respectively in grams and W is the weight of the sample in grams

Test results were recorded in grams per 100 grams of sample and to one decimal place. (AOAC, 2003)

FORMULA USED TO CALCULATE FOR PERCENTAGE CRUDE FAT

$$\%\text{Crude fat} = \frac{\text{Weight of ether extract}}{\text{Weight of sample}} \times 100$$

(AOAC, 2003)

FORMULA USED FOR THE CALCULATION OF PERCENTAGE CRUDE ASH

$$\%\text{Ash} = \frac{\text{Difference in Weight of Ash}}{\text{Weight of sample}} \times 100$$

(AOAC, 2003)