THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Microbial Contamination in Water Used for *Fufu* Production in Selected Traditional Catering Establishments in the Cape Coast Metropolis, Ghana

Juliana Tawiah
Lecturer, Food and Nutrition, OLA Training College, Cape Coast, Ghana
Faustina Yaa Amoako-Kwakye
Senior Lecturer, West End University College, Ghana

Abstract:
The study investigated possible microbial contamination of water used in fufu production. The experimental study design was used to test samples of source water and water used in turning fufu collected from two licensed and two unlicensed chop bars and a third licensed one used as control selected from the Cape Coast Metropolis based on stratification. (ICOSFUP, an instrument for collecting data on safety practices in fufu production was also used for observation. Samples used for laboratory analyses were collected from source water for turning fufu and water for turning fufu were tested using the multiple tube fermentation and membrane filtration analytical methods. The data were presented in tables of frequencies, percentages, while regression analysis was used to
Among the key findings were that all the tests proved positive for biological parameters. The possible contamination of the water for turning the fufu was from the untreated source water and human factors including failure to wash hands. The interventions impacted positively in reducing the microbial contamination greatly. The recommendation is that District Assemblies, Food and Drugs Authority, through the District Health Directorate should set up task forces to educate, monitor and enforce good hygienic practices by all chop bar operators.

Keywords: *Microbial parameters, contamination, multiple tube fermentation, membrane filtration, interventions*

1. Introduction

1.1. Background to the Study

Food may be cooked at home or bought from vendors such as restaurants and cafés. With the ever-increasing pace of humans' lifestyles; women in full employment, business booms, expansion of tourism, among others, it has become necessary for people to eat ready-to-eat convenience foods outside the home. This has contributed to the increasing number of food vending outlets globally. According to Rande (1996), foods prepared or eaten outside the home are less expensive, cooked in just a matter of minutes, and very much accessible. This gives low-income earners the opportunity to afford food, helps people to do away with the difficulty in preparing food at home, gives people many new choices in the food to eat and affords them the joy of eating foods of ethnic delicacy. Despite these advantages with foods prepared and served outside the home, Lelieveld (2000) pointed out that those foods are usually highly contaminated or face a greater risk of contamination. To Lelieveld, surveillance and monitoring by a number of countries indicates that food-borne illness is increasing around the world. As such issues on contaminated foods have become a global concern, especially with the increase in the number of food vendors and joints. Lelieveld thus advises that with recent increases in events concerning the contamination of various foods, it is important to know and understand the sources and mechanisms (practices) of food contamination. Lelieveld (2003) noted that the main types of food contaminants are microbiological, chemical and physical.

According to Wilson and Droby (2000), food contaminants are introduced into food at numerous stages right from the farm to the point of consumption. The authors argued that the kitchen, kitchen staff, tools and equipment for cooking need to be cleaned to ensure that raw food which has been kept safe and clean from the farm through its transportation and supply is not contaminated at the cooking or preparation stage.

United Nations International Children Education Fund [UNICEF] (2011) said that Africa had seen more than 85,000 reported cases of cholera, resulting in 2,466 deaths. The size and scale of the outbreaks meant that the region was facing one of the biggest epidemics in its history. In addition, case fatality rates were unacceptably high, ranging from 2.3-4.7% and could reach much higher levels at the district level in many countries (ranging from 1-22% in Cameroon, for example).

The case of Ghana is not different from the rest of the African countries. Ministry of Health [MOH] (2003) indicated that the most commonly occurring food-borne diseases in Ghana are typhoid, cholera and diarrhoea. The Ministry established that food-borne diseases from contaminated food and/or water are the fourth largest causes of illnesses after malaria. Ghana Broadcasting Corporation [GBC] (2011) specified that approximately 5,614 cholera cases; a food-borne disease, and 69 deaths had been recorded nationwide by the Ghana Health Service since the outbreak began by the end of 2010. The reports indicated that in the Central Region the number of food contamination cases increased to 71 with two deaths in five days within the third quarter of 2011.

With the belief that the catering industry is the primary source of food-borne outbreaks, Oti-Mensah (2005) reported that the increase in food vending outlets, particularly the traditional catering establishments, accounted for the increase in food contamination cases in the country. The New Harmonised Standards for Accommodation and Catering Establishment by the Ghana Tourism Authority (2003) classified traditional catering under the informal catering sector. The sector encompasses all traditional catering establishments such as drinking bars, snack bars, wayside catering, home catering and chop bars. Chop bars, as part of the traditional catering establishments, are noted to serve local foods, including *fufu* (pounded boiled starchy root and plantain) with soup.

Bidawid, Farber and Sattar (2000) argued that foods sold at traditional catering establishments, stand a high risk of contamination which is transmitted to their consumers. Bidawid et al. believed that most food contamination incidences are as a result of mishandling food, which include, keeping food at the wrong temperature, leaving food at room temperature for too long, incorrect re-heating, and cross contamination.

In 2003, the Central Region recorded 7,017 typhoid cases out of which 1,008 were from the Cape Coast Metropolis. Statistics on diarrhoea and cholera cases in the metropolis were also 3,693 and 221, respectively. The annual report of the Cape Coast District Community Health Centre [CCDCHC] (2004) portrayed that there had been an annual increase in the number of reported food-borne diseases.

A study by MacArthur and Abane (2010) on "The compliance with food safety measures by traditional caterers in the Cape Coast Municipality" revealed that food, especially *fufu* sold in chop bars in the Cape Coast Metropolis, was highly contaminated with coliform and *salmonella* bacteria. However, the source of the contamination was not examined. It was in line with this concern, coupled with the prevalence of food-borne diseases in the metropolis that this study was undertaken as a follow up, to examine the possible sources of contamination in *fufu* production in selected licensed and non-licensed traditional catering establishments (chop bars) in the metropolis, starting with the water used in the production process.

The purpose of this study was to investigate possible microbial contamination of water in *fufu* production in selected licensed and non-licensed traditional catering establishments (chop bars) in the Cape Coast Metropolis.

1.2. Research Questions

The study sought to answer the following questions:

1. What are the levels of microbial contamination of source water used in *fufu* preparation in the four selected chop bars in the Cape Coast metropolis?
2. What are the levels of microbial contamination of water for turning the *fufu* during *fufu* preparation in the four selected chop bars?
3. What practices are likely to introduce micro-organisms into water for *fufu* production in the four selected chop bars?
4. What are the differences between the microbial loads of water used for *fufu* production in the four selected chop bars?
5. What impacts will the adopted intervention measures have on the microbial contamination of water for *fufu* production?
6. What contributions will the two kinds of water make towards the quality of *fufu* produced?

1.3. Research Hypotheses

1. H_0. There are no significant differences between source water and microbial loads of water used for *fufu* production.
2. H_0. There are no significant differences between the microbial loads in the water used for turning fufu for the experimental and control group.

2. Methodology

2.1. Research Design

The study adopted an experimental research designs. The researcher controls the effects of other strenuous variables that might also influence the degree of change in the dependent variable as the independent variable changes. The independent variables used in this research were various processes *fufu* undergoes but in this study, the only issue in the processes was the water used, whilst the dependent variable was the level of microbial load in the water used in the *fufu* preparation.

2.2. Population, Sample and Sampling Procedure

The population for the study comprised traditional catering establishments in Cape Coast. At the time of the study, there were only 18 licensed chop bars on the Ghana Tourism Authority's classification of the catering establishments. The non-licensed chop bars comprised 17 that were accessible. A proportionate calculation of 20% was then applied on these groups to arrive at four and three bars respectively. The 20% proportionate calculation was based on the assertion by Creswell (2004) that where key informants are used, 20% of the sample is adequate. This meant that the sample of licensed and non-licensed chop bars selected for the study were four and three respectively in each case.

On getting to the field however, some of the sampled chop bars were not willing to be involved in the study. Only two from each group indicated their willingness to participate in the study. One of the licensed chop bars was randomly sampled using the lottery method and that constituted the experimental chop bar. The basis for using an experimental chop bar was to note if there would be any momentous change in the microbial load in *fufu* after introducing interventional measures.
The number of traditional catering establishments involved in the study was satisfactory because adequate *fufu* and water specimen could be obtained for the analysis, Again, the nature of the production activities for *fufu* were uniform, because of the common traditional procedures used in the preparation of *fufu.*
In all, 40 samples were taken on different days within a given period from the two selected chop bars, comprising 36 samples from the four study chop bars and four from the control. The control chop bar was to note if there would be any momentous change in the microbial load in *fufu* after intervention.

2.3. Instruments
The instrument considered for the study was guided observation. An audit tool that was developed by MacArthur and Abane (2010) from the International Code of Hygienic Practice for street food vending was adopted, modified and code-named instrument for collecting data on safety practices in *fufu* production (ICOSFUP). The tool was employed for a non-participant observation of hygienic practices of chop bar operators, where the observer watched the situation openly without participating in any of the activities (Burns, 2000).

2.4. Data Collection Procedure
The aims of the study were explained and permission sought to collect samples and observe the conducts of the vendors during the production of *fufu.* Producers who gave their consent and offered to take part in the study were assured of maximum confidentiality and anonymity. Three weeks were used to observe the practices of the food vendors in the selected chop bars. The observation was done 14 times to include all the selected chop bars to determine the consistency of the practices used in *fufu* preparation.
Three samples were taken on each visit to a selected chop bar (samples of *fufu*, samples of water used before, and after turning the *fufu*). Samples were collected in triplicate to establish the validity obtained. The samples were then subjected to laboratory analysis.

a. *Fufu* ($_1$)
b. source of water for turning *fufu* ($_2$)
c. water used for turning *fufu* (during the pounding of *fufu*) ($_3$)

Samples of *fufu* and water were obtained early in the morning. The temperatures of all water samples were taken at the point of sample collection and upon arrival at the laboratory where analyses were carried out. This was done because temperature influences microbial activity and change in temperature on transit to the laboratory recorded as this could influence microbial load. *Fufu* was collected into food flasks that had been cleaned with methylated spirit to exclude all micro-organisms that might have been harboured there. Water samples were also collected in sterile wide-mouthed bottles with dust-proof ground glass stoppers. Care was taken during the collection of water samples to prevent contamination and then sent to two laboratories namely: Ghana Water Company, Cape Coast and Water Research Institute, Accra.
One chop bar was considered for experimental treatment by using the first two HACCP principles to minimise microbial load in water for *fufu* production. All tools and equipment were boiled and in addition, the hands of both the person pounding and the one turning the *fufu* were washed with soap and water and finally rinsed. In the other chop bars, cold water was used to turn *fufu* and also cold water was used to wash all the equipment and utensils used.
Before testing the water samples, the whole laboratory, including floor, equipment including petri dishes, fermentation and sample bottles and pipettes were sterilized by autoclaving and left to cool at ambient temperature before use. Ethanol was then used to clean all work and sachet surfaces. Control measures and precautions to prevent recontamination

2.5. Data Analysis
Measures of central tendency in terms of mean, mode and standard deviation (as a measure of dispersion) from the Statistical Product for Service Solutions (SPSS) software Windows version 17 was used to analyse the data. The samples collected were analysed using two analytical methods (multiple tube fermentation and membrane filtration). The analysis was done by using the means of the results. Independent sample t-test was used to test for significant differences between the licensed and non-licensed traditional catering establishments. In all cases, an error margin of 0.05 was used to test for the significance. Regression analysis was used to analyse the first research question. The laboratory results were also used to test the hypothesis.

2.6. Conceptual Framework
The Hazard Analysis and Critical Control Points in relation to the Crosby's Total Quality Management Theory can be used to assess hazards in *fufu* preparation in traditional catering establishments. Crosby's (1996) preventive theory contended that quality in safety standards leads to the achievement of desired results.

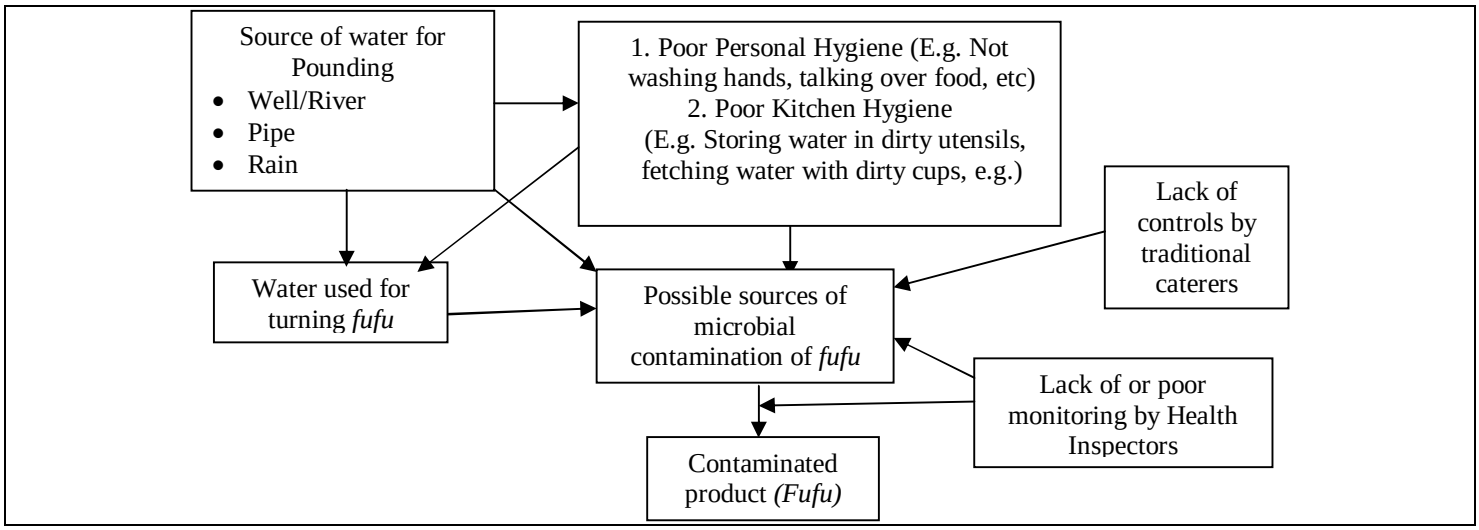

Figure 1: Model for the Study
Source: Author's Construct, 2016

3. Results and Discussion

The mean temperatures of test samples from selected chop bars were first taken and they were found to range between 33.2°C and 36.1°C. These were found to be within the Temperature Danger Zone (TDZ) of figures ranging from 4^0 to 60^0C.

3.1. Levels of Microbial Contamination in the Water Used

In the production of *fufu*, after the staples have been boiled, the next stages where contamination is likely to occur are first, the source water used for the *fufu*, then the mortar, the pestle and lastly the water used in turning the *fufu*. The first attempt at identifying where to put in the necessary control measures to reduce or avoid contamination in *fufu* production as explained by the HACCP system, was considered to be the water used.

Results for the multiple tube and membrane filtration analyses have been presented in Tables 1 and 2 and 3 and 4 respectively. Total coliform, faecal coliform, and *E. coli* were the parameters analysed by using the multiple tube analysis. All analyses of samples were in triplicate, so Tables 1 to 4 represent mean loads present in the water samples from the selected chop bars. To make the presentation and discussion of results clearer, the results for all parameters for individual chop bars after which comparison among chop bars were also considered.

Microbiological parameters	**Samples**				
	AL_1	AL_2	CU_1	CU_2	
Total coliform	1300	1600	825	1350	
Faecal coliform	48	402	5.0	32	
E. coli	18	192	0.0	0.9	

Table 1: Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Licensed 'A' and Unlicensed 'C' Chopbar Water Samples
Source: Laboratory Results, 2016

Data presented in Table 1, show that the recorded load for the biological parameters analysed for source water for pounding *fufu* from licensed chop bar A (AL_1) were: total coliform, 1300 MPN/100ml, faecal coliform 48 MPN/100ml and *E. coli* 18 MPN/100ml. Samples collected from the water used for turning *fufu* which was labelled licensed chop bar A (AL_2) had MPN/100ml for total coliform count was 1600; the faecal coliform and *E. coli* counts were 402 MPN/100ml and 192 MPN/100ml respectively.

Data in Table 1 show the results of that the recorded mean loads for the biological parameters analysed in the sample from source of water for pounding *fufu* in Unlicensed chop bar C (CU_1) were: total coliform, 825 MPN/00ml, faecal coliform 5.0 MPN/100ml and E. coli 0.0 MPN/100ml. Samples collected from the water used for turning *fufu* in unlicensed chop bar C (CU_2) had 1350 MPN/100ml counts for total coliform. The faecal coliform obtained in sample C CU_2 was 32 MPN/100ml and 0.9 MPN/100ml was obtained for E. coli.

3.2. Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Licensed and Unlicensed 'B' and C Chop Bar Water Samples

The second set of tests was conducted on samples from licensed Chop Bar 'B' Table 2 presents results on mean most probable number for microbiological contamination in the preparation of *fufu* for licensed Chop Bar 'B'.

Microbiological parameters	Samples				
	BL_1	BL_2	DU_1	DU_2	
Total coliform	45	1339	1600	1650	
Faecal coliform	10	40	5.0	202	
E. coli	0.3	13	0.1	89	

Table 2: Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Licensed 'B' and 'Unlicensed 'D' Chop bar Water Samples
Source: Laboratory Results, 2016

As shown in Table 2, the recorded load for sample BL_1, which was taken from the source of water for pounding *fufu* from Licensed chop bar B, for the biological parameters analysed were: total coliform, 45 MPN/100ml, faecal coliform 10 MPN/100ml and E. coli 0.3 MPN/100ml. Results from the samples collected from the water used for turning *fufu,* from the same Licensed chop bar B (BL_2) $_{gave}$ 1339, 40 and 13 MPN/100ml for total coliform, faecal coliform and E. coli.
Table 2 also shows that mean bacterial loads for sample DU_1, being the source of water for pounding *fufu* in Unlicensed chop bar D, for the biological parameters analysed were: total coliform, 1600 MPN/100ml, faecal coliform 5.0 MPN/100ml and E. coli 0.1 MPN/100ml. Samples collected from the water used for turning *fufu* after the process was over in Unlicensed chop bar D (DU_2) had MPN/100ml for total coliform count of 1650; the faecal coliform obtained was in sample D was 202 MPN/100ml and 89 MPN/100ml was obtained for E. coli.

3.3. Membrane Filtration Analysis of Samples for the Two Licensed and Two Unlicensed Selected Chop Bars
As earlier stated, analysis of samples was conducted on the same samples with two different analytical methods for verification of results obtained in the use of the first method (multiple tube fermentation) and to ascertain whether differences existed in microbiological load of results of the two methods. It should also be noted that additional parameters such as yeast, mould and total heterotrophic bacteria were analysed since the media for analysing the parameters were available. The microbiological parameters were measured in mean number of colony forming units (CFU/1ml for total heterotrophic and CFU/100ml for other microbiological parameters).

3.4. Mean Number of Colony Forming Units (CFU)/1ml for TH and (CFU)/100ml for the Microbiological Parameters in the Licensed and Unlicensed Chop Bars 'A' and C" Water Samples
Tables 3 and 4 present results of membrane filtration analysis of the samples from the four selected chop bars (two licensed and two unlicensed).

Microbiological parameters	Samples				
	AL_1	AL_2	CU_1	CU_2	
Total coliform	1544	1830	240	1058	
Faecal coliform	111	182	6	123	
E. coli	47	86	1	72	
Total Heterotrophic	3968	5880	1565	10368	
Mould	1227	0.6	24	7.0	
Yeast	2.0	449	0.0	160	

Table 3: Mean Number of Colony Forming Units (cfu/1ml) for TH and (cfu)/100ml for Other Microbiological Parameters in Licensed and Unlicensed Chop bars 'A' and 'C' Water Samples
Source: Laboratory Results, 2016

As shown in Table 3, the recorded load for sample AL_1, which was taken from the source of water for pounding *fufu* in chop bar A for the biological parameters analysed were: total coliform, 1544 cfu/100ml, faecal coliform 111 cfu/100ml, *E. coli* 47 cfu/100ml, total heterotrophic bacteria 3968 cfu/1ml, mould 1227 cfu/1ml and 2.0 cfu/ml for yeast. The results from the table again indicate that for sample AL_2, cfu/100ml for total coliform count was 1830; the faecal coliform obtained was in sample L_2 from chop bar A was 182 cfu/100ml and 86 cfu/100ml for *E. coli*, total heterotrophic bacteria 5880 cfu/1ml, mould 0.6 cfu/1ml and 449 cfu/1ml for yeast respectively.
The mean recorded loads for samples in unlicensed chop bar 'C' in Table 3, reveal that the recorded load for sample CU_1, which was taken from the source of water for pounding *fufu* for the biological parameters analysed were: total coliform, 240 cfu/100ml, faecal coliform 6.0 cfu/100ml, *E. coli* 1.0 cfu/100ml, total heterotrophic bacteria 1565 cfu/1ml, mould 24 cfu/1ml and 0.0 cfu/1ml for yeast.
The results from unlicensed chop bar C indicate that the results from the source water sample CU_2 were: cfu/100ml for total coliform count was 1058; the faecal coliform obtained was in sample 'C' was 123 cfu/100ml and 72 cfu/100ml for *E. coli*, total heterotrophic bacteria 10368 cfu/1ml, mould 0.7 cfu/1ml and 160 cfu/1ml for yeast.

3.5. Mean Number of Colony Forming Units (CFU)/1ml for TH and (CFU)/100ml for other Microbiological Parameters in Licensed and Unlicensed Chop bar 'B' and 'D' Water Samples

The level of microbiological contamination of samples chop bars 'B' and D was also examined in this study. Details of the results are presented in Table 4.

Microbiological parameters	Samples				
	BL_1	BL_2	DU_1	DU_2	
Total coliform	1592	1460	18	4430	
Faecal coliform	3.0	195	6.0	551	
E. coli	0.0	92	1.0	160	
Total Heterotrophic	4608	3233	109	5299	
Mould	16	1.0	27	689	
Yeast	17	704	0.0	400	

Table 4: Mean Number of Colony Forming Units (cfu)/1ml for TH and (cfu)/100ml for Other Microbiological Parameters in Licensed and Unlicensed Chop bars 'B' and 'D' Water Samples
Source: Laboratory Results, 2016

Table 4 portrays the results of analyses of samples in licensed and unlicensed chop bars 'B' and 'D'. The recorded load for sample BL_1, as shown in the table, which was taken from the source of water for pounding *fufu* for the biological parameters analysed were: total coliform, 1592 cfu/100ml, faecal coliform 3.0 cfu/100ml, *E. coli* 0.0 cfu/ 100ml, total heterotrophic bacteria 4608 cfu/1ml, mould 16 cfu/1ml and 17 cfu/1ml for yeast. Samples (CU_2) of water for turning *fufu* taken from licensed chop bar B(BL_2) yielded cfu/100ml for total coliform count was 1460; the faecal coliform obtained was 195 cfu/100ml and 92 cfu/100ml for *E. coli*, total heterotrophic bacteria 3233 cfu/1ml, mould 1.0 cfu/ 1ml and 322 cfu/1ml for yeast respectively.

Table 4 shows that recorded load for sample DU_1 from unlicensed chop bar 'D', which was taken from the source of water for pounding *fufu* for the biological parameters analysed were: total coliform, 18 cfu/100ml, faecal coliform 6.0 cfu/100ml, *E. coli* 1.0 cfu/100ml, total heterotrophic bacteria 10 cfu/1ml, mould 27 cfu/1ml and 0.0 cfu/1ml for yeast. The results from the chop bar D (DU_1), as presented in the table, indicate that cfu/100ml for total coliform count was 4430; the faecal coliform obtained was 551 cfu/100ml and 160 cfu/100ml for *E. coli*, total heterotrophic bacteria 5299 cfu/1ml, mould 689 cfu/1ml and 400 cfu/1ml for yeast respectively.

4. Discussion

With regard to the Multiple Tube Fermentation Test, the results of water samples from the two licensed and two unlicensed chop bars presented in Tables 1 and 2 indicate that the source water used for the production of *fufu* contained some microbial parameters and the water for turning *fufu* had higher loads in all the cases. The highest recorded faecal coliform (202MPN/100ml) and *E. coli* (192MPN/100ml) were in samples drawn from the water used for turning *fufu*. However, it can be deduced that the source of the water used in pounding *fufu* was microbiologically contaminated and could either introduce contaminants into the *fufu* or contribute to increased microbiological load.

A comparison of the eight results of water recorded for the two licensed and two unlicensed chop bars reveals that the lowest contamination of faecal coliform were the samples of water for turning *fufu* (5 MPN/100ml) from unlicensed chop bars 'C' and 'D'. *E. coli* recorded the lowest count in the source water with 0.3 MNP/100ml from licensed Chop bar B. Faecal coliform counts started with a relatively small load in BL_1 which increased at the end of the process (BL_2).

Tables 3 and 4 present the eight tests for from source water were quite high in most cases. The results obtained from mould Membrane Filtration in the two licensed and two unlicensed chop bars. Total coliform in the samples analyses in *fufu* production also depict that water used for turning *fufu* tested positive with a relatively high figure, while water used for turning *fufu* recorded a much lower level of 1.0 cfu/1ml. A high level of total heterotrophic contamination was recorded with sample from the source water, while the least was recorded with the water for turning *fufu*. Contamination of the water for turning the *fufu* could be due to direct human contact.

In comparing the results from the four chop bars, the least numbers of bacteria in the source water samples were: Total coliform (18 cfu/1ml) from unlicensed chop bar 'D', Faecal coliform bacteria from licensed chop bar 'B'(3 cfu/1ml), no E. *coli* in licensed chop bar 'B', Total heterotrophic form licensed chop bar 'D', mould 16 (cfu/1ml) from licensed chop bar 'B' and no yeast was found in the samples from unlicensed chop bars C and 'D'.

In the water for turning *fufu*, the least numbers of bacteria obtained were: Total coliform (4430cfu/1ml) from unlicensed chop bar 'D', Faecal coliform bacteria from unlicensed chop bar 'D' (551cfu/1ml), E. *coli* in unlicensed chop bar 'D', Total heterotrophic form unlicensed chop bar 'D' (10368cfu/ml), mould (1227cfu/ml) from licensed chop bar 'A' and no yeast was found in the samples from licensed chop bar 'B'.

Generally, the third phase of the discussion is based on a comparison of the results from the two tests; Most Probable Number and Membrane Filtration analyses for licensed chop bar 'A' respectively, depict that the samples taken from the water for turning *fufu* in most cases had higher values than the source water. In all cases values far exceeded the permitted levels by both Australia/New Zealand (2002) and Ghana Standards Authority [GSA] (2009). Logically, it was expected that contamination would increase from (source water) to the water for turning *fufu*. However, this was not the case since the pattern of multiplication was not consistent along the path. The source of water used by Chop bar 'A' was tap water, which was expected not to have harboured any biological

contaminants since it is supposed to be treated water. The presence of contaminants could have been from the sanitary conditions of the taps, containers used in fetching water and those who fetched the water could be possible sources of contamination.

The pattern of load for faecal coliform *and E. coli* did not also follow any consistent pattern; however, it deviated from the pattern presented by total coliform contamination. Water for turning *fufu* recorded the highest load for the two parameters (faecal coliform and *E. coli*) and this could be as a result of the foam used in absorbing the liquid from the mortar. Water for turning *fufu* recorded the least load by the membrane filtration analysis.

The trend of contamination from faecal coliform and *E. coli* could be said to have followed a fluctuating pattern by both analytical methods. Observed increase in contamination along the production line in all cases could only be attributed to the human factor, that is, absence of personal hygiene practices like: not washing hands after visiting places of convenience, picking of nose, wearing long nails, not changing into sanitized work clothes before work, not having a clean bath, among others, before handling food. All these practices could account for increased faecal contamination in the water for turning *fufu*. The far-reaching reduction of mould levels of water for turning *fufu* could be attributed to the regular changing of the water during *fufu* pounding, and the high temperature of the *fufu.*

The trend of load of contaminants recorded for samples from licensed chop bar 'B' reveals that the pattern of load was not the same for the two analytical methods (Tables 3 and 5). While the source water (BL_1) registered the least load (45 MPN/100ml and increased to 1339 MPN/100ml at the end of the process (BL_2) for multiple tube fermentation analysis. Water for turning *fufu* for both analyses was expected to have much higher counts considering the fact that there were organisms present in the source water, the load in source water decreased at the end of the process with the membrane filtration analysis although the difference was marginal. The possible explanation that could be accorded the observed decreased load of total coliform in is that the high temperature of the cooked staples might have killed some of the organisms in the *fufu.* The obvious explanation for the increase in load of total coliform could be that the water was not changed often and therefore residues from mortar and pestle found their way into that sample. The organisms therefore could have been transferred from food handlers, water used and the equipment for food processing and the boiling of the staples before pounding. In other words, the increased temperature of the staples might have killed some of the faecal coliforms in both mortar and pestle during pounding. The high contamination of yeast in *fufu* can be attributed to yeast contamination in the source water. This means that attempts to avoid yeast *fufu* at licensed Chop bar 'B' should focus on eliminating yeast contamination from the source water for pounding. This is in line with the HACCP principle that total food quality can be achieved through a systematic preventive approach to food safety by addressing physical, chemical, and biological hazards as a means of preventive rather than being reactive to the anticipated hazard.

A comparison of the level of load for source water and the water for turning *fufu* for membrane filtration analysis and multiple tube fermentation analysis indicates marked differences between each pair of values for total coliform. The difference in the level of total coliform contaminants in the source water and water used for turning *fufu* suggests that more total coliform from the mortar and pestle were introduced into CU_2 during pounding considering the values of the former.

The water source in chop bar C was a well and the presence of total coliform presupposes that the water was not clean enough. It is commonly assumed that groundwater which includes well water is the purest source of water because it is naturally filtered when it passes through several layers of rocks and sediments in an aquifer. However, the results obtained from a study by Omari and Yeboah-Manu (2012) on bacterial contamination of drinking water sources at Mpraeso, Ghana, showed that groundwater sources are as polluted as surface water sources. For this reason, however, it is important that groundwater undergoes treatment before usage. For instance, chop bar operators who use well water should boil it to make it safe, especially for the fact that *fufu* is not given further treatment before consumption. The explanation that could be given for the presence of high load of faecal coliform and *E. coli* in samples from mortar and pestle is that initial load could have been small but having been left overnight; multiplication could have been enhanced by the favourable temperature and the presence of moisture if the equipment were not dried. Temperature of *fufu* after preparation were within the Temperature Danger Zone (TDZ), that is 4-60^{o}C, where micro-organisms thrive and multiply at a rapid rate hence, the unacceptable levels of microbial load.

A critical examination of Tables 3 and 4, which present the results of both multiple tube fermentation and membrane filtration analysis for unlicensed chop bar 'D' reveal that the source water recorded the least count in all parameters. Contamination of the source water with the presence of microbial loads in the parameters was not expected, but they being there could have been due to the fact that the water was not hygienically stored since the source water was from the tap, which many Ghanaians assume to have received technological treatment. A lot of ignorance is exhibited by many Ghanaians, who do not think about the fact that the pipes through which the water flows and the fact that some of the pipes pass through filthy surroundings often get exposed and burst and so can introduce a lot of microorganisms into the pipe borne water.

The high levels of faecal coliform and *E. coli* in the multiple tube fermentation analysis (Table 2) was not matched by the membrane filtration results (Table 4). The trend is quite surprising since membrane filtration analysis is thought to be sensitive and for that matter able to filter as many of the organisms as possible. The alternate assumption for this trend could be overestimation of load with multiple tube fermentation analysis results. Obviously, application of contaminated water to *fufu* was likely to add to the load already in the *fufu* sample and most often than not, water used for turning *fufu* may have originated from the mortar and pestle. This may also be attributed to the high contamination of the source water with faecal coliform hence, application of such water to the *fufu*, could have reduced the temperature of the boiled staple and made it ambient for the multiplication of the faecal coliform. Organisms in the *fufu* could have also been present in the raw ingredients and escaped cooking temperatures since most caterers reported that they looked for good bargain rather than checking for acceptable organoleptic properties of food (MacArthur & Abane, 2010).

It can be deduced from the foregoing discussion that contamination of *fufu* occurs due to certain practices embarked on by *fufu* handlers. The results presented so far imply that microbiological parameters could be eliminated or significantly reduced from the *fufu* production process when deliberate attempts are made to properly clean the items with hot water. Thus, Whitney et al. (2005) argued that temperature regulation at the various stages in food production is critical for achieving total food quality. LeJeune and Kauffman (2005) also added that *E. coli* is easily killed by heating. These assertions also corroborate with the third principle of the HACCP food safety approach by Price, Stevenson and Tom. (1993) which posited that there should be established preventive measures, such as temperature control to manage critical limits at each critical point in the food preparation process. Such measures may include checking the source of water for cleaning the mortar and pestle and for turning *fufu.* The water could be boiled before use to reduce all forms of microbiological contaminations from the final stage. Additionally, the pans that hold the source water for pounding *fufu* should be thoroughly cleaned, not to be put on bare floor and those who pound the *fufu* should also observe good hygienic practices.

It should be noted that in all cases membrane filtration values were higher than multiple tube fermentation values. This observation may be attributed to the fact that due to its sensitivity the former analytical method is able to capture almost all organisms present in any given sample. The latter analytical method on the other hand just estimates the load of organisms that may be present in the sample which may not always give the true picture of what is present in the sample, hence the disparity (Edberg, Rice., Karlin., & Allen (2000)).

3.6. Practices Likely to Introduce Micro-Organisms into Water used in Fufu Production

Results from the audit tool developed by MacArthur and Abane (2010) from ICOSFUP showed that the three topmost practices likely to introduce micro-organisms into *fufu* production as far as water used was concerned were: the use of untreated water to turn *fufu* (86%, n = 12), and hands not properly washed before turning *fufu* (71%, n = 10).

It was observed in some of the chop bars that untreated water (well) was used to turn *fufu* in the preparation process. Since the quality of water from such wells could not be guaranteed, there was the likelihood of introducing microbiological parameters into the *fufu.* Such waters could contain *E. coli* which can be killed through boiling. Omari and Yeboah-Manu (2012) corroborated this finding by reporting on a study at Mpraeso, Ghana that groundwater or stagnant water sources are as polluted as surface water sources. For this reason, however, it is important that groundwater or stagnant water undergo treatment before usage.

Improper washing of hands before turning *fufu* constituted a major source of microbial load. Dirty hands and nails harbour germs which when not properly washed infects anything the hand touches. The hands should therefore be washed with soap and clean water and rinsed before turning. Hartman (2001) stressed that *fufu* when fingernails of food vendors are not trimmed and filed, they allow dirt and micro-organisms to collect beneath them and thereby contaminate the *fufu.* Hardy (1999) also emphasized that personal hygiene, particularly hand washing, remains a key intervention strategy in food preparation premises, and must be reinforced on a near constant basis.

With a lot of houseflies hovering around the premises, utensils and food in some of the selected chop bars, it was possible that the direct contact of utensils was a source of contamination. The implication is that if the dishes were not washed properly before using it to keep turning water, the microbiological parameters were likely to be introduced into the *fufu* production process.

The awareness of the practices likely to introduce microbiological parameters in *fufu* will help vendors to avoid or improve on their activities to eliminate microbiological parameters in the food. According to Lelieveld (2000), knowledge of the route of food contamination is critical to developing methods to control access of some micro-organisms in the food, and in understanding the most effective mechanisms of intervention. Observation data was used to analyse the practices likely to introduce microbiological parameters in *fufu.*

3.7. The Contribution Made by Source Water and Water for Turning Fufu in the Microbiological Parameters in Fufu Production

Regression analysis was used to examine the contribution made by source water and water for turning *fufu* in the microbiological parameters in *fufu* production. To achieve these, *fufu* samples produced from the four chop bars using the water were tested. In all cases, an error margin of 0.05 was used to test for the significance. Table 5i, ii and iii present the details.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.893	0.797	0.755	1288.65

Table 5i: Model Summary of Regression Analysis
Source: Laboratory results, 2016

Predictors: (Constant), water used for turning *fufu,* source water for pounding *fufu,* sample from the pestle, sample from the mortar.

3.8. Hypotheses Testing

As presented in Table 5i, a model summary on how microbiological parameters in the *fufu* production predict the level of microbiological contamination in the *fufu* samples. An adjusted R Square value of 0.755 implies that 75.5% of changes in the microbiological parameters of *fufu* samples were explained by the microbiological parameters in the other variables (source water, sample from the mortar, sample from the pestle, and water for turning *fufu*). This implies that other variables explain 24.5% of variations in the microbiological parameters of *fufu* samples.

Model		Sum of squares	df	Mean Square	F	Sig
1	Regression	1.241E8	4	3.101E7	18.68	0.001
	Residual	3.155E7	19	1660609.49		
	Total	1.556E8	23			

Table 5ii: ANOVA
Source: Laboratory Results, 2016

a. Predictors: (Constant), water used for turning *fufu*, source water, sample from the pestle, sample from the mortar
b. Dependent Variable: sample *fufu*

Table 5ii presents the significance of the analysis of variance in the changes in microbiological parameters of *fufu* sample explained by the microbiological parameters from the other stages in the *fufu* production process (predictors). From Table 5ii, a Sig. value of 0.001 implies that the microbiological parameters from the other stages in the *fufu* production process had significant effect on the microbiological parameters in the *fufu* sample. Thus, the Sig. value of 0.001 was within the acceptable error margin value of 0.05.

Model		Unstandardised Coefficients		Standardised Coefficient	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-240.32	407.24		-590	0.562
	Source water for pounding *fufu*	0.497	0.249	0.243	2.00	0.060
	Sample from the mortar	0.008	0.166	0.009	0.05	0.960
	Sample from the pestle	0.390	0.147	0.390	2.65	0.016
	Water used for turning *fufu*	0.491	0.167	0.485	2.94	0.008

Table 5iii: Coefficients
Source: Laboratory Results, 2016
Dependent Variable: Sample fufu

It is evident from Table 5iii that water used for turning *fufu* made the strongest unique contribution (Beta = 0.485) to explaining variations in microbiological parameters in *fufu*, when the variance explained by all other variables in the model was controlled for. Comparing the Sig. value of 0.008 with the alpha value of 0.05 implies that the effect of water used for turning *fufu* on the microbiological parameters in *fufu* from the selected chop bars was statistically significant. This could be explained by the fact that the water used for turning *fufu* gets mixed with the *fufu.*
Table 5iii again show that source water for pounding *fufu* made the also made a strong unique contribution (Beta = 0.497) to explaining variations in microbiological parameters in *fufu*, when the variance explained by all other variables in the model was controlled for. When the Sig. value of 0.060 with the alpha value of 0.05 implies that the effect of source water used in the *fufu* production on the microbiological parameters in *fufu* from the selected chop bars was not statistically significant. This shows that water for turning *fufu* is the critical control points for eliminating microbiological parameters. This means that efforts to eliminate microbiological parameters from *fufu* should focus on avoiding microbiological parameters in the water used for turning *fufu.*
Constructing regression equation for the possible sources of microbiological parameters in *fufu* as far as water from the selected chop bars shows that: Possible sources of microbiological parameters in *fufu* = –240.32 + 0.497 (source water for pounding *fufu*) + 0.008 (sample from the mortar) + 0.390 (sample from the pestle) + 0.491 (water used for turning *fufu*).

5. Conclusions

1. Both the Multiple Tube Fermentation for Mean Most Probable Number (MPN)/100ml and the Membrane Filtration (cfu/1ml) Analyses results for determining main sources of microbial contamination of water used in *fufu* preparation in licensed and non-licensed chop bars test samples after boiling the staples indicated that faecal coliform and *E. coli*, moulds and yeasts were found in all the *fufu* samples from both the licensed and unlicensed chop bars.
2. The (MPN)/100ml revealed that faecal coliform and *E. coli* from the water used for turning the "fufu" were higher than all the results obtained from the four chop bars and these were all in the samples from Chop Bar A, a licensed chop bar. Again, in the Membrane Filtration Analysis for mean number of colony forming units, TH and (cfu)/100ml for other microbiological parameters, in all cases, the membrane filtration values were higher than multiple tube fermentation values.
3. The microbiological parameters from water used for turning *fufu* on the microbiological parameters in *fufu* from the selected chop bars were statistically significant.
4. The use of untreated water to turn *fufu* and improper washing of hands before pounding and turning *fufu* are two topmost practices likely to introduce micro-organisms into *fufu* production process. Other sources of contamination could have emanated from actions, which included picking of nostrils, scratching of hair, rubbing of hands on the skin, irregular changing of water for turning *fufu*, poor storage of water for pounding *fufu.*

6. Recommendations

The following recommendations for policy and practice have been made based on the findings of the study and the specific parts to be played.

A. For Chop Bar Operators

Personal, food and kitchen hygiene practices should be strictly observed by chop bar operators. Personal hygiene, which includes having regular bath, changing of clothes from the house into clean working before cooking, washing hands before cooking and after visiting the toilets, avoidance of picking of nostrils, scratching of hair, rubbing of hands on the skin, among others. Food hygiene include using warm water to turn *fufu*, using soap and water to wash hands before turning and pounding *fufu*, and regularly changing the water for turning *fufu*, proper storage and using clean water for pounding *fufu;*

B. The Ministry of Health, Ghana Health Services, District Assemblies

The Ministry of Health, Ghana Health Services, the Regional and District Assemblies should set up task forces to monitor chop bar operators so that they observe and maintain the listed personal, food and kitchen hygienic practices all times in the catering industry in the municipality and its environs.

C. The Food and Drugs Authority, Ghana Tourism Authority and Public Health Agencies

These bodies should step up their monitoring and regulatory activities over licensed chop bars by collecting samples of *fufu* to test occasionally so that actual microbial load can be assessed. This will help to improve the practices at the chop bars and to reduce the levels of microbial load in *fufu* production to the acceptable standards.

Finally, a combined action by the Ministry of Health, Ghana Health Services, Regional and District Assemblies, the Food and Drugs Authority and the Ghana Tourism Authority should organise quarterly training programmes such as in-service training courses, seminars and workshops on the hygienic standards to be practised and maintained at all chop bars so as to meet the microbiological qualities of *fufu* in Ghana and the international arena.

7. Suggestions for Further Studies

The following have been suggested for further studies;

1. All the HACCP principles should be used to analyse the stages in the production of *fufu* to prevent contamination in the food before completion.
2. The utensils and service bowls after completion of *fufu* production should be tested for contamination.

8. References

i. Alli, I. (2004). Food quality assurance: Principles and practices. New York: CRC Press LLC.
ii. Burns, R. B. (2000). Introduction to research models. London: Sage Publications.
iii. Cape Coast District Community Health Centre. (2004). 2003 annual report. Cape Coast: Ministry of Health.
iv. Cape Coast Metropolitan Assembly. (2006). Medium-term development plan. Retrieved October 4, 2011, from http://www.ghanadistrict.com/centralregion /capecoastmetropolis
v. Codex Alimentarius Commission. (2003). Recommended international code of practice: General principles of food hygiene including Annex on Hazard Analysis Critical Control Point (HACCP) and guidelines for its application. CAC/RCP 1–1969 Rev 4.
vi. Crosby, P. B. (1996). Quality is still free: Making quality certain in uncertain times. New York: McGraw-Hill Book Company.
vii. Bidawid, S., J. M. Farber, and S. A. Sattar (2000). Contamination of foods by food handlers: ... Retrieved on 20th October, 2016
viii. www.foodprotect.org/issues/packets/2014Packet/attachments/III_014__all.pdf
ix. Edberg, S. C., Rice, E. W., Karlin, R. J., & Allen, M. J. (2000). Escherichia coli: the best biological drinking water indicator for public health protection. Applied and Environmental Microbiology Journal, 88, 1068-1168.
x. Ghana Broadcasting Corporation. (2011). Ghana-Cholera. Retrieved October 24, 2011, from http://www.gbcghana.com/index.php?id=1.340472
xi. Ghana Standards Authority. (2009). Quality requirements for food. Accra, Ghana: GSA.
xii. Ghana Tourism Authority. (2003). New harmonised standards for accommodation and catering establishments in Ghana. Accra: Ghana Tourism Authority.
xiii. Hardy, A. (1999). Food, hygiene, and the laboratory. A short history of food poisoning in Britain, circa 1850-1950. Social History of Medicine, 12, 293-311.
xiv. Hartman, P. A. (2001). The evolution of food microbiology. In M. P. Doyle, L. R. Beauchat, & T. J. Montville (Eds.). Food microbiology: Fundamentals and frontiers (2nd ed.). Washington DC: ASM Press.
xv. LeJeune, J. T., & Kauffman, M. D. (2005). Effect of sand and sawdust bedding materials on the faecal prevalence of Escherichia coli O157:H7 in dairy cows. Applied and Environmental Microbiology, 71, 326-330.
xvi. Lelieveld, H. L. M. (2000). Hygienic design of factories and equipment. In B. M. Lund, A. C. Baird-Parker, & Gould, G. W. (Eds.). The microbiological safety and quality of food. Gaithersburg: Aspen Publishers Inc.
xvii. Lelieveld, H. L. M. (2003). Sources of contamination. In H. L. M. Lelieveld (Ed.). Hygiene in food processing (pp. 61-75). Cambridge: Woodhead Publishing Ltd.

xviii. MacArthur, R. L., & Abane, A. M. (2010). Compliance with food safety measures by traditional caterers in the Cape Coast Metropolis. International Journal of Home Economics, 2 141-152
xix. Ministry of Health. (2003). Morbidity, age and sex. Cape Coast: Ministry of Health.
xx. Omari, S., & Yeboah-Manu, D. (2012). The study of bacterial contamination of drinking water sources: A case study of Mpraeso, Ghana. The Internet Journal of Microbiology, 10, 1.
xxi. Oti-Mensah, M. A. (2005). Catering made easy. Accra: Martmag Publications.
xxii. Price, J., Stevenson, K. E., & Tom, P. D. (1993). Ensuring food safety: The hazard analysis and critical control point (HACCP) way. California: Department of Agriculture.
xxiii. Rande, W. L. (1996). Professional food service. New York: John Wiley & Sons, Inc.
xxiv. Safe Drinking Water Foundation. (2007). Heterotrophic plate count. Retrieved May 15, 2013 from http://www.who.int/water_sanitation_health/dwq/en/HPC 2.pdf
xxv. United Nations International Children Education Fund. (2011). Africa: Food- and water-borne illness outbreaks. Retrieved October 24, 2011, from http://www. unicef.org/media/media_60032.html
xxvi. Whitney, E., Rolfes, S. R., & Wadsworth, T. (2005). Understanding nutrition (10th ed.). New York: McGraw-Hill Inc.
xxvii. Wilson, C. L., & Droby, S. (2000). Microbial food contamination. Florida: CRC Press.