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Sources of Microbial Contamination of "Fufu" Production in Ghana: Selected Licensed and Non-licensed Chop Bars in Cape Coast Metropolis

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Abstract

The study investigated the possible sources of contamination in "fufu" production in selected licensed and non-licensed traditional catering establishments (Chop Bars) in the Cape Coast Metropolis. A guided observation schedule (ICOSFUP) was used to record unhygienic practices from the chop bars. Specimens of source of water for turning "fufu", mortar, pestle, "fufu" and water for turning "fufu" were analysed for total heterotrophic bacteria, yeast and mould, total coliform bacteria, faecal coliform bacteria, and E. coli on Nutrient Agar, OGYE Agar, M-Endo Agar, MacConkey Faecal Coliform Agar, and Hichrome Agar respectively. Both the Multiple Tube Fermentation and Membrane Filtration methods were used for the analysis. It was found out that water used for turning "fufu" made the strongest unique contribution (Beta = 0.485) to the microbial contamination of "fufu". All the microbiological parameters tested for far exceeded their standardized limits in "fufu" (16.5-5983.25 cfu/1ml/100ml). Findings of the study indicated that there is high amount of microbial contamination in "fufu" being sold and consumed in Cape Coast metropolis. The study recommended that all chop bar operators should implement the adopted intervention measures to reduce the sources of microbial contamination of "fufu" and to make "fufu" wholesome for human consumption.

Keywords

Microbial, Contamination, "Fufu" Licensed, Non-Licensed, Chop Bar, Cape Coast, Metropolis, Central Region of Ghana

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1. Introduction and Background

Food is vital to life because it plays many functions in man. Without food, man's survival will be at risk. Food taken into the human body performs three main functions [1]. These functions are building, repairing and replacement of body tissues; production of heat and energy for work and warmth; and protection from diseases, and regulation of body processes. Foods prepared or eaten outside the home are less expensive, cooked in just a matter of minutes, and very much accessible [2]. 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, those foods are usually highly contaminated or face a greater risk of contamination [3]. 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

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number of food vendors and joints. 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 [3].

The sources and practices that introduce contaminants to food include improper washing of hands and fingernails; improper handling, preparing, and storing of food items or food; poor personal hygiene habits of food employees; improperly cleaned and sanitised eating and cooking utensils and equipment, contamination of food, utensils, and equipment from flies, cockroaches, and other insects and pests, and cross contamination, storage and cooking temperatures. Food contaminants are therefore introduced into food at numerous stages right from the farm to the point of consumption [4].

With the belief that the catering industry is the primary source of food-borne outbreaks, that increases in food vending outlets, particularly the traditional catering establishments, accounted for the increase in food contamination cases in the country [5]. The New Harmonised Standards for Accommodation and Catering Establishment by the Ghana Tourism Authority classified traditional catering under the informal catering sector [6]. 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, "akple" (a fermented maize and cassava dumpling) with okro soup, "waakye" (boiled rice and beans), "kontomire" stew and boiled plantain or yam, stew and boiled rice, fried fish with pepper sauce and kenkey, and a lot more.

"Fufu" is a traditional dish that goes through several stages during its preparation. Again, it is highly patronised by several people, both literates and illiterates and so the problem of examining the particular points of contamination becomes even more relevant for public health. Statistics shows that sicknesses due to food contamination are prevalent in Cape Coast Metropolis more than any other district of the Central Region [7, 8]. Questions which keep arising include the following: After the staples are boiled and allowed to cool, how safe is "fufu" from the time pounding starts to when it is completed? How clean are the mortars and pestles? How clean is the source of water and also the water used for turning "fufu"? What is the microbial load of the finished "fufu" at the time it is served to people? A study 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 [9].

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 motived the researchers to undertake this study 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. The purpose of this study was to investigate the possible sources of contamination in "fufu" production in selected licensed and non-licensed traditional catering establishments (chop bars) in the Cape Coast Metropolis. The study was guided by Research Hypothesis: H_o: There is no significant difference in the microbial load of "fufu" served in the selected licensed and non-licensed chop bars. H_1: There is significant difference in the microbial load of "fufu" served in the selected licensed and non-licensed chop bars.

2. Review of the Literature

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 [3]. there are three main types of food contaminant which are microbiology, chemical and physical which are the recognised categories of food safety hazards or contaminants are biological, chemical and physical [10, 11]. The origin of these hazards in foods can be from naturally occurring substances or usually from decomposition of foods, improper handling, harvesting, preparation, or food storage. Foods can become contaminated during growth and harvesting of raw materials, storage and transport to the factory, and processing into finished products. Final product may then become re-contaminated during subsequent storage and transport to shops, and during storage and preparation by the consumer [4].

The main sources of contamination are the environment, animals and people whilst the main transmission routes (vectors) of contamination are contaminated surfaces, air, water, people and pests [10]. Processing, packaging material and equipment, and transport vehicles may also act as vectors. However, contact between food material and inert surfaces leave residual food debris that favours the growth of micro-organisms [12].

Over time, micro-organisms can multiply to significant numbers and become endemic in a processing plant [13]. Chemical contamination may also result from contact with surfaces, if they are not adequately rinsed after cleaning and disinfection [14]. A study on Production *and use of food-grade lubricants* indicated that lubricants, often unavoidable in equipment with moving parts, may also contribute to chemical contamination. Non-contact surfaces, such as floors,

walls, ceilings, overhead beams and equipment supports, are potential reservoirs of microbial contamination and can also be a source of physical and chemical contaminants, for example, from flaking plaster and its associated chemicals. They need to be designed so that they are durable and can be cleaned effectively [14].

Fresh vegetables and grains can harbour pathogens or mycotoxins without any discernible loss of quality [15]. Out of the eight most cited sources of food contamination on *Safe food handling: Training manual for managers of food service establishments* conducted posit that isolated cross contamination as the most singular source responsible for food contamination [16]. The transfer could be direct contact between one food and another; from food handlers who do not wash their hands between handling raw and cooked food; or indirect contact, which is between equipment and improper storage practices [17].

Animals can be a source of harmful micro-organisms. Production animals are important reservoirs of micro-organisms and slaughtered animals introduce large numbers of micro-organisms into the processing plant. Among them are many zoonotic pathogens that are present on the skin and in the gastro-intestinal and respiratory tracts. Pathogens carried on hands are also a major source of contamination [18]. Food from animals and their manures can therefore carry human pathogens without any clinical manifestations.

Air can be a significant medium for the transfer (vector) of contaminants to food products [19]. Unless the air is filtered, micro-organisms will be present, and air may also carry light foreign bodies, such as dust, straw-type debris and insects. Chemical taints can enter the production area through airborne transmission. Water is used in the food industry as an ingredient, a processing aid and for cleaning. Its use as an ingredient or processing aid can give rise to both microbial and chemical contamination. It is therefore important to use water of a high microbiological and chemical quality [14].

Water can be a carrier of many micro-organisms including pathogenic strains of *E. coli*, *Salmonella* spp., *Vibrio cholerae*, *Shigella* spp., *Cryptosporidium parvum*, *Giardia lamblia*, *Cyclospora cayetanensis*, *Toxiplasma gondii,* and the Norwalk and hepatitis A viruses. Water used in hand washing facilities poses a potential problem. Water does that from condensation of steam or water vapour, leaking pipes and drains, and rainwater [20]. Stagnant water is particularly hazardous, since microbial levels can increase rapidly under favourable conditions [20]. This assertion is buttressed in the results obtained from a study on bacterial contamination of drinking water sources at Mpraeso, Ghana, that groundwater or stagnant water sources are as polluted as surface water sources [21]. For this reason, however, it is important that groundwater or stagnant water undergo treatment before usage.

Water contents in food can adversely increase microbial load in food, it was therefore of the view that, bacteria require an adequate amount of moisture to survive. Micro-organisms usually receive their food in the form of liquid because, they cannot ingest their food. If the amount of moisture is lowered, bacterial activity is reduced and will eventually stop. This principle makes drying and freezing an effective form of preservation. The water content of many fresh foods ranges from 60-95%. The water content of dehydrated foodstuffs is kept vanishingly small in order to prolong shelf-life [2, 22].

Sufficient moisture, abusive temperature, and adequate time will ensure a continuing increase in the bacterial population on fruits and vegetables, particularly in fresh-cut products. Amount of time food is kept at a temperature makes most bacteria to function effectively within a certain range of conditions. Food passes through critical temperatures of which some are upper safe zone (cooking temperatures ranging from 60-127°C), danger zone for bacterial growth also referred to as temperature danger zone (4-60°C) and finally lower safe zone (-18-4°C). Upper safe zone has temperature high enough to kill most bacteria and this usually is above and at boiling points of cooking. It again has a holding temperature which slows the growth of bacteria. Different foods support different strains of harmful bacteria, so it is important to cook food items to the proper internal temperature. Most bacteria action occurs within the range called temperature danger zone (TDZ) which is at both room and body temperature. Food spends time at room temperature while being prepared, and once it enters the human body the temperature is very conducive to growth. The third critical temperature (lower safe zone) comprises three different points namely: refrigerator temperatures (cold food storage refrigeration), freezing point (subfreezing) and freezer temperatures (freezer storage). The lower safe zone slows bacteria growth and at the same time helps store food best for long term [2].

Personnel can also transfer enteric and respiratory pathogens to food. Pathogens can be transferred through aerosol droplets from coughing near the processing line. People can equally be vectors of physical contaminants, such as hair or fingernail fragments, earrings, plasters and small personal belonging [13, 23]. Pests, such as birds, insects and rodents, are potentially a major contamination problem, and particular care needs to be taken to prevent their entry into food production areas [4]. Buildings must be designed to keep pests, insects and rodents out. Floors, ceilings and walls should not allow insects and other invertebrates the chance to live and breed to contaminate food. Basically, the movement of food through various stages such as receiving, storage, preparation and service until it gets to the final customer

poses high risk of food contamination [24]. Good hygienic practices before, during, and after food preparation can reduce the chances of contracting an illness. Since all food-borne diseases are associated with poor hygienic practices, it is important to look into such practices. Food handlers play an important role in the transmission of food-borne viruses since they are a primary source of cross contamination. The transfer of the micro-organism from food handlers to food can come from their skin, nose and bowel. Food service workers are unaware of how to protect food from the threat of contaminants. The handling of food involves washing, cleaning, peeling, slicing, dicing and cutting in its preparation. With cross contamination, bacteria can spread to clean food from contaminated food through direct contact, surfaces and equipment [25].

Bad serving practices also cause food contamination. The link between the production area and the customer is the service area of the food service operation [4]. Serving is the last step in the production process and it is crucial to the customers dining enjoyment. The customers' impressions of the food service operation may be determined by the service and the quality of service the operation provides [26]. However, if food handlers practice bad serving habits which are able to contaminate food before it gets to the customer, the customer will suffer from food-borne illnesses. These bad food handling and serving practices include servers keeping long fingernails which are able to hold dirt beneath nails and are likely to drop into food which is just to be consumed [27].

A study on street foods in Accra, Ghana revealed that raw materials for the preparation of food in Ghana were potentially capable of supporting vegetative and spore forms of bacteria due to their origin from the soil, poor hygiene and storage practices. The assertion presupposes that pathogenic microbes contaminate food from human and environmental sources all of which are channels of cross contamination, and the major risk being attributed to the food handler [28].

3. Methodology

The study adopted an experimental research design. The experimental research design allows researchers to test for the effect of changes in an independent variable on a dependent variable. Experimental research design is useful for scientific or laboratory studies [29]. The independent variables used in this research were various processes "fufu" undergoes, whilst the dependent variable was the level of microbial load in "fufu". This helped to ascertain the critical control points for microbial infestation

The population for the study comprised traditional catering establishments in the Cape Coast Metropolis. The traditional catering establishments were of two classes, that is licensed, and non-licensed. According to the records available at the Ghana Tourism Authority, there are 35 traditional catering establishments in the Cape Coast Metropolis [10]. These comprised 18 licensed, and 17 non-licensed catering establishments.

The sample size used for the study was four chop bars made up of two licensed and two non-licensed chop bars. 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 where key informants are used, 20% of the sample is adequate [30].

The instrument considered for the study was guided observation schedule. An assessment tool 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) [9]. A guided observation schedule (ICOSFUP) was used to record unhygienic practices from the chop bars. Specimens of source of water for turning "fufu", mortar, pestle, "fufu" and water for turning "fufu" were analysed for total heterotrophic bacteria, yeast and mould, total coliform bacteria, faecal coliform bacteria, and E. coli on Nutrient Agar, OGYE, Agar, M-Endo Agar, MacConkey Faecal Coliform Agar, and Hichrome Agar respectively.

Statistical Product for Service Solutions (SPSS) software Windows version 16.0 was used to analyse the data. The specimen collected were analysed using two analytical methods (multiple tube fermentation and membrane filtration). The analysis was done by using the means of the results. Regression analysis and laboratory results were used to examine the critical control points of microbiological parameters in "fufu" production.

4. Findings and Discussions

This section analysed stages in the production of "fufu" where contamination was likely to occur after boiling the staples. This was necessary to put in control measures to reduce or avoid contamination at the critical points in "fufu" production as explained by the HACCP system. Critical points of food contamination allow people and organisations to predict potential risks to food safety and to prevent them before they happen [31].

Since analysis of specimen were in triplicate, results of the analysis illustrated in Tables 1-8 represent mean microbial loads present in specimen from the selected chop bars. In order to identify the sources of "fufu" contamination at the pounding stage, specimen were drawn at different points and analysed. To make the presentation and discussion of results clearer, the section focused on the result for all parameters

for individual chop bars after which comparison among chop bars were also considered.

Results for the multiple tube analyses and membrane filtration analyses have been presented in Tables 1-4 and 5-8 respectively. Total coliform, faecal coliform, and *E. coli* were the parameters analysed by using the multiple tube analysis. Total heterotrophic, mould and yeast were however, not analysed due to the fact that, there were no media in the laboratory where such methods of analyses were conducted. The mean most probable number (MPN/100ml) for the parameters (total coliform, faecal coliform, *E. coli*) for Chop Bars 'A' to 'D' are presented in Tables 1-4. All parameters analysed with the exception of some parameters in the experimental group tested positive by the two analytical methods contrary to the contention that these parameters should not be found in food [32]. The details are presented according to the chop bars dealt with starting from Chop Bar 'A'. The results from the tests carried out in licensed Chop Bar 'A' can be seen in Table 1.

Table 1 presents mean most probable number (MPN)/100ml of test specimen in licensed Chop Bar 'A'. From Table 1, the biological parameters analysed were total coliform (1300 MPN/100ml), faecal coliform (48 MPN/100ml) and *E. coli* (18 MPN/100ml). The specimen from mortar, also showed positive result for total coliform (4014 MPN/100ml), faecal coliform (22 MPN/100ml) and *E. coli* (10 MPN/100ml).

Table 1. Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Licensed Chop Bar 'A' Test Specimen.

Microbiological parameters	Specimen				
	Source water	Mortar	Pestle	"Fufu"	Turning water
Total coliform	1300	4014	2310	2172	1600
Faecal coliform	48	22	225	174	402
E. coli	18	10	103	80	192

The specimen from pestle gave 2310 MPN/100ml for total coliform. The faecal coliform present was 225 MPN/100ml while *E. coli* had 103 MPN/100ml counts. The "fufu" specimen had 2172 MPN/100ml of total coliform. The faecal coliform and *E. coli* counts were 174 and 80 MPN/100ml respectively. Specimens were also collected from the water used for turning "fufu"; total coliform, faecal coliform and *E. coli* counts were 1600, 402 and 192 MPN/100ml respectively.

A comparison of the results, as presented in Table 1, indicate that the highest mean most probable number of total coliform was mortar. However, in the same mortar, the faecal coliform count was the lowest, with 22 MPN/100ml and *E. coli* 10 MPN/100ml. On the other hand, the highest recorded faecal coliform and *E. coli* were obtained in specimen drawn from the water used for turning "fufu".

An observation made in Chop Bar 'A' during data collection was that the one turning the "fufu" kept adding water to the "fufu" being pounded to facilitate the softening of the "fufu". After the "fufu" had reached its elastic limit, she used foam to mop the excess water left in the mortar. This was an improper hygienic practice and could compromise the quality of the food since the foam was not sterilized and not new either. The pestle specimen had the second highest count for faecal coliform and *E. coli*. This was an indication that the pestle was also contaminated and all these were likely to get to the final product. The results clearly show 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 if control measures are not put in place to prevent growth and development or multiplication with favourable conditions. Usually, before and after pounding, most "fufu" vendors do not use hot water in washing the mortar and the pestle. At best, they will remove the "fufu" stuck to the mortar and pestle and keep it for the next day without even covering it. There is therefore the likelihood of contamination by bacteria in the dust on where the pestle is stored. The second set of tests was conducted on specimen 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'. As shown in Table 2, the recorded load for the source of water for pounding "fufu" revealed 45 MPN/100ml for total coliform, 10 MPN/100ml for faecal coliform and 0.3 MPN/100ml for *E. coli*. The specimen from mortar also showed positive results for total coliform (1600 MPN/100ml), faecal coliform (110 MPN/100ml) and *E. coli* (40 MPN/100ml).

Table 2. Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Licensed Chop Bar 'B' Test Specimen.

Microbiological parameters	Specimen				
	Source Water	Mortar	Pestle	"Fufu"	Turning Water
Total coliform	45	1600	1625	1754	1339
Faecal coliform	10	110	90	67	40
E. coli	0.3	40	40	20	13

The specimen from pestle gave 1625 MPN/100ml for total coliform. The faecal coliform present was 90 MPN/100ml and *E. coli* was 40 MPN/100ml. The "fufu" specimen from Chop Bar 'B' had 1754 MPN/100ml for total coliform. The

faecal coliform present was also 67 MPN/100ml and 20 MPN/100ml for *E. coli*. Specimen was also collected from the water used for turning "fufu. The results indicated 1339, 40, and 13 MPN/100ml for total coliform, faecal coliform and *E. coli* respectively.

A comparison of the results in Table 2 showed that total coliform recorded 45-1754 MPN/100ml with "fufu" recording the highest total coliform count. The sample that recorded the second highest count was specimen from pestle (1625 MPN/100ml) followed by that of the mortar (1600 MPN/100ml). Table 2 further shows that the lowest contamination of faecal coliform in licensed Chop Bar 'B' recorded was for the source water sample (10 MPN/100ml), while the highest recorded was for the specimen from the mortar (110 MPN/100ml). Specimen from the pestle was the second highest source of faecal contamination (90 MPN/100ml) followed by that of the "fufu" (67 MPN/100ml) and then water for pounding "fufu" (40 MPN/100ml). *E. coli* recorded the lowest count in the source water with 0.3 MNP/100ml, while specimen from the mortar and pestle recorded the highest with 40 MNP/100ml each. While specimen from mortar was the major source of faecal coliform contamination in the case of *E. coli*, it was the mortar together with the pestle. *E. coli* contamination, however, reduced in the "fufu" specimen with 20 MPN/100ml. Faecal coliform and *E. coli* contamination for Chop Bar 'B' followed the same trend. It started with a relatively small load in B_1 which increased at the end of the process (B_5) while specimen B_2, B_3 and B_4 either hovered around the same figure or followed a decreased load.

There were also test for microbiological loads in "fufu" in two non-licensed chop bars. The aim was to examine sources, types and levels of contamination in "fufu" preparation. Table 3 presents microbiological load in the "fufu" preparation process in non-licensed Chop Bar 'C'. A study of the data presented in Table 3 show that the recorded mean loads taken from the source of water for pounding "fufu" contained total coliform of 825 MPN/00ml, faecal coliform of 5 MPN/100ml and *E. coli* of 0.0 MPN/100ml. The specimen from mortar, also showed positive results for total coliform (3479 MPN/100ml), faecal coliform (20 MPN/100ml) and *E. coli* (0.3 MPN/100ml). The specimen from pestle gave 2570 MPN/100ml for total coliform. The faecal coliform present was 22 MPN/100ml and 0.4 MPN/100ml for *E. coli*. The "fufu", specimen from Chop Bar 'C' had 1567 MPN/100ml for total coliform. The faecal coliform present was 20 MPN/100ml while *E. coli* recorded 0.4 MPN/100ml.

Table 3. Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Non-Licensed Chop Bar 'C' Test Specimen.

Microbiological parameters	Specimen				
	Source Water	Mortar	Pestle	"Fufu"	Turning Water
Total coliform	825	3479	2570	1567	1350
Faecal coliform	5	20	22	20	32
E. coli	0.0	0.3	0.4	0.4	0.9

Specimens were also collected from the water used for turning "fufu". The results indicate that 1350 MPN/100ml counts were obtained for total coliform. The faecal coliform obtained was 32 MPN/100ml and 0.9 MPN/100ml was obtained for *E. coli*. From Table 3, the least recorded total coliform was from the source of water, while the specimen from the mortar recorded the highest load. The second highest total coliform was recorded in the specimen from the pestle, followed by the "fufu" sample. The least recorded faecal coliform in the test specimen for non-licensed Chop Bar 'C' was with the source water, while the highest recorded load was water used for turning "fufu". The results imply that the mortar and pestle introduced *E. coli* in the "fufu" preparation process.

The second non-licensed chop bar specimen dealt with were those from Chop Bar 'D'. Table 4 portrays the level of microbiological load of parameters examined in test specimen for non-licensed Chop Bar 'D'.

Table 4. Mean Most Probable Number (MPN)/100ml for Microbiological Parameters in Non-Licensed Chop Bar 'D' Test Specimen.

Microbiological parameters	Specimen				
	Source Water	Mortar	Pestle	"Fufu"	Turning Water
Total coliform	1600	1800	2025	2200	1650
Faecal coliform	5	200	205	270	202
E. coli	0.1	49	70	74	89

Table 4 shows that mean bacterial loads taken from the source of water for pounding "fufu" contained 1600 MPN/100ml total coliform, 5 MPN/100ml faecal coliform and 0.1 MPN/100ml *E. coli*. The specimen from mortar also showed positive result for total coliform (1800 MPN/100ml), faecal coliform (200 MPN/100ml) and *E. coli* (49 MPN/100ml). The specimen from pestle gave 2025 MPN/100ml for total coliform. The faecal coliform present was 205 MPN/100ml and that for *E. coli* was 70 MPN/100ml. The "fufu" specimen from Chop Bar 'D' had 2200

MPN/100ml for total coliform. The faecal coliform present was also 270 MPN/100ml and 74 MPN/100ml for *E. coli*. Specimens were also collected from the water used for turning "fufu" after the process was over. The results indicated that MPN/100ml for total coliform count was 1650; the faecal coliform obtained in specimen D_5 was 202 MPN/100ml and that of *E. coli* was 89 MPN/100ml.

Table 4 shows that all the stages in the "fufu" preparation process tested positive for total coliform. Total coliform in the specimen from source water, mortar, pestle and "fufu" indicated an increasing pattern of load while water for turning "fufu" deviated from this trend. Faecal coliform contamination on the other hand ranged from 5 MPN/100ml to 270 MPN/100ml with the source water recording the least level of contamination, and "fufu" specimen recording the highest load. Specimen from the mortar and pestle were obviously the major sources of faecal coliform contamination in non-licensed Chop Bar 'D'. Table 4 also presents the level of contamination of *E. coli* in the "fufu" preparation process for Chop Bar 'D' and the results in the table indicate that all the stages in the "fufu" preparation process tested positive with *E. coli*.

As earlier stated, analysis of specimen were conducted on the same specimen 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. Another reason for using the second analytical method was the fact that there were no media for analysing the other parameters that were analysed in the second laboratory. The microbiological parameters in membrane filtration analyses were measured in mean number of colony forming units (cfu/1ml for total heterotrophic, and cfu/100ml for other microbiological parameters). It should also be noted that additional parameters such as yeast, mould and total heterotrophic bacteria were analysed using the membrane filtration method. The analyses were made possible because of the availability of the media for analysing the parameters.

Tables 5-8 present results of membrane filtration analysis of the specimen from the four selected chop bars (two licensed and two non-licensed).

Table 5. Mean Number of Colony Forming Units (cfu)/1ml for TH and (cfu)/100ml for other Microbiological Parameters in Licensed Chop Bar 'A' Test Specimen.

Microbiological parameters	Specimen				
	Source water	Mortar	Pestle	"Fufu"	Turning water
Total Heterotrophic	3968	8336	3138	6668	5880
Yeast	2.0	704	841	119	449
Mould	1227	1711	1443	253	0.6
Total coliform	1544	7477	5727	5130	1830
Faecal coliform	111	2900	639	244	182
E. coli	47	2655	322	27	86

Table 5 portrays the result of analysis of specimen in licensed Chop Bar 'A'. Table 5 indicated that counts of the biological parameters recorded for source of water for pounding "fufu" were total coliform 1544 cfu/100ml and faecal coliform 111 cfu/100ml. *E. coli* had a count of 47 cfu/100ml, total heterotrophic bacteria 3968 cfu/1ml, mould 1227 cfu/1ml and yeast 2.0 cfu/ml. Specimen from mortar also showed positive results for total coliform (7477 cfu/100ml), faecal coliform (2900 cfu/100ml), *E. coli* (2655 cfu/100ml), total heterotrophic (8336 cfu/1ml), mould (1711 cfu/1ml) and yeast (704 cfu/1ml).

The specimen from pestle gave 5727 cfu/100ml for total coliform. The faecal coliform and *E. coli* present in the specimen were 639 and 322 cfu/100ml respectively. Total heterotrophic bacteria 3138 cfu/1ml, mould 1443 cfu/1ml and yeast 841 cfu/1ml were the figures recorded for the pestle specimen. The "fufu" specimen from Chop Bar 'A' had 5130 cfu/100ml for total coliform. The faecal coliform present was 44 cfu/100ml while *E. coli* was 27 cfu/100ml. The "fufu" specimen also recorded total heterotrophic bacteria of 6668 cfu/1ml, mould 253 cfu/1ml and 1192 cfu/1ml for yeast. Specimens were also collected from the water used for turning "fufu". The results indicate that cfu/100ml for total coliform count was 1830, faecal coliform recorded 182 cfu/100ml while *E. coli* recorded 86 cfu/100ml. Counts for total heterotrophic bacteria was 5880 cfu/1ml, mould 0.6 cfu/1ml and yeast 449 cfu/1ml. Table 5 gives an indication of the specimen that recorded high and least figures for the various parameters analysed. With the exception of yeast and mould, specimen from mortar recorded the highest load in all the parameters followed by specimen from the pestle. However, levels of yeast and mould in specimen from pestle were higher than that of the mortar. The least level of load of parameters in specimen analysed, however, did not follow any definite pattern; it varied from one parameter to another. While source water recorded least level of total coliform and yeast, *E. coli* and faecal coliform were less in the "fufu" sample. Specimen from pestle and water for turning "fufu" also recorded least level of load in total heterotrophic bacteria and mould respectively. The level of microbiological contamination at the various stages in "fufu" production in licensed Chop Bar 'B'

was also examined in this study. Details of the results are presented in Table 6.

Table 6. Mean Number of Colony Forming Units (cfu)/1ml for TH and (cfu)/100ml for other Microbiological Parameters in Licensed Chop Bar 'B' Test Specimen.

Microbiological parameters	Specimen				
	Source water	Mortar	Pestle	"Fufu"	Turning Water
Total Heterotrophic	4608	6317	4690	4604	3233
Yeast	17	704	704	384	322
Mould	16	708	994	8.0	1.0
Total coliform	1592	5112	3829	1445	1460
Faecal coliform	3.0	2333	390	45	195
E. coli	0.0	1097	211	15	92

Table 6 portrays the result of analysis of specimen in licensed Chop Bar 'B'. The recorded load for 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. Specimen from mortar also showed positive result for total coliform (5112 cfu/100ml), faecal coliform (2333 cfu/100ml) and *E. coli* (1097 cfu/100ml), total heterotrophic (6317 cfu/1ml), mould (708 cfu/1ml) and yeast (704 cfu/1ml). The specimen from pestle gave 3829 cfu/100ml for total coliform. The faecal coliform was 390 cfu/100ml while *E. coli* recorded 211 cfu/100ml. Total heterotrophic bacteria 4690 cfu/1ml, mould 994 cfu/1ml and 704 cfu/1ml for yeast were the figures recorded for specimen on pestle. The "fufu", specimen from chop bar 'B' had 1445 cfu/100ml for total coliform. The faecal coliform present was also 45 cfu/100ml and 15 cfu/100ml for *E. coli*. The specimen also recorded 4604 cfu/1ml for total heterotrophic bacteria, 8.0 cfu/1ml for mould and 384 cfu/1ml for yeast. Specimens were also collected from the water used for turning "fufu" after the production process.

The results from Table 6 indicate that 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 loaded 3233 cfu/1ml, mould 1.0 cfu/1ml and 322 cfu/1ml for yeast respectively. Table 6 also shows that faecal coliform contamination levels were much lower compared to the observed huge total coliform levels. It is also evident from Table 6 that almost all the stages in the "fufu" preparation tested positive for *E. coli* with the exception of source of water. The level of microbial contaminants was further reduced comparing faecal coliform levels to that of *E. coli*.

It is also evident in Table 6 that total heterotrophic bacteria was positive in all the specimen analysed and also the highest recorded levels among the other parameters tested in the specimen. Results obtained from mould analyses in "fufu" production also depict that all but water used for turning "fufu" tested positive with relatively high figures. The least load which is from water used for turning "fufu" recorded 1.0 cfu/1ml while pestle recorded the highest load with 994 cfu/1ml. The highest level of total heterotrophic contamination was recorded with specimen from the mortar, 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.

However, the low contamination of mould in the "fufu" and water used to turn "fufu" could be due to the fact that the mortar and pestle were well washed and rinsed with clean water before pounding "fufu", as well as the boiling of the staples before pounding "fufu". The results mean that proper washing of the utensils, as well as the mortar and pestle is critical for reducing mould contamination in "fufu" production. The contamination of yeast in the "fufu" sample can be attributed to the yeast contamination in the source water for pounding "fufu", mortar and pestle. This means that attempts to avoid yeast contamination in "fufu" at licensed Chop Bar 'B' should focus on eliminating yeast contamination from the source water for pounding "fufu", mortar and pestle. 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.

Table 7 portrays the result of analysis of specimen in non-licensed Chop Bar 'C'. The third samples dealt with in this section were the specimen from the non-licensed Chop Bar 'C'. The details are presented in Table 7. The mean recorded loads for specimen in Chop Bar 'C' in Table 7, reveal that the recorded load for the specimen 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 specimen from mortar also showed positive result for total coliform (5901 cfu/100ml), faecal coliform (1197 cfu/100ml), *E. coli* (625 cfu/100ml), total heterotrophic (7466 cfu/1ml), mould (594 cfu/1ml) and yeast (456 cfu/1ml). The specimen from pestle recorded 6053 cfu/100ml for total coliform. The faecal coliform present in the specimen was 500 cfu/100ml and 294 cfu/100ml for *E. coli* respectively. Total heterotrophic bacteria 7520 cfu/1ml, mould 1700

cfu/1ml and 924 cfu/1ml for yeast were the figures recorded from the pestle.

Table 7. Mean Number of Colony Forming Units (cfu)/1ml for TH and (cfu)/100ml for other Microbiological Parameters in Non-Licensed Chop Bar 'C' Test Specimen.

Microbiological parameters	Specimen				
	Source Water	Mortar	Pestle	"Fufu"	Turning Water
Total Heterotrophic	1565	7466	7520	4804	10368
Yeast	0.0	456	924	5.0	160
Mould	24	594	1700	382	7.0
Total coliform	240	5901	6053	1070	1058
Faecal coliform	6.0	1197	500	10	123
E. coli	1.0	625	294	6.0	72

Notably, the "fufu" specimen from Chop Bar 'C' had 1070 cfu/100ml for total coliform. The faecal coliform present was 10 cfu/100ml and 6.0 cfu/100ml for *E. coli*. The specimen also recorded total heterotrophic bacteria of 4804 cfu/1ml, mould 382 cfu/1ml and 5.0 cfu/1ml for yeast. Specimens were also collected from the water used for turning "fufu". The results indicate that cfu/100ml for total coliform count was 1058, faecal coliform 123 cfu/100ml, *E. coli* 72 cfu/100ml, total heterotrophic bacteria 10368 cfu/1ml, mould 7.0 cfu/1ml and yeast 160 cfu/1ml.

As shown in Table 7, faecal coliform contamination levels were much lower compared to the observed huge total coliform levels. It is also evident from Table 8 that all the stages in the "fufu" preparation tested positive for *E. coli*. The level of microbial contaminants was further reduced comparing faecal coliform levels to that of *E. coli*. Specimen from the water for turning "fufu" recorded a value as high as 10368 cfu/1ml, while specimen from the source of water for pounding "fufu" recorded the least total heterotrophic contamination of 1565 cfu/1ml. Results obtained from mould analyses in "fufu" production also depict that all but water used for turning "fufu" tested positive with relatively high figures. The least load which was from water used for turning "fufu" recorded 7.0 cfu/100ml while pestle recorded the highest load with 1700 cfu/100ml.

Table 8 shows details of the analyses of microbiological parameters in the test specimen for non-licensed Chop Bar 'D'.

Table 8. Mean Number of Colony Forming Units (cfu)/1ml for TH and (cfu)/100ml for other Microbiological Parameters in Non-Licensed Chop Bar 'D' Test Specimen.

Microbiological parameters	Specimen				
	Source water	Mortar	Pestle	"Fufu"	Turning Water
Total Heterotrophic	109	7100	7709	7857	5299
Yeast	0.0	660	955	485	400
Mould	27	1404	1598	720	689
Total coliform	18	6700	7473	6832	4430
Faecal coliform	6.0	1022	489	41	551
E. coli	1.0	426	394	18	160

Table 8 shows that recorded loads for source of water for pounding "fufu" were total coliform 18 cfu/100ml, faecal coliform 6.0 cfu/100ml, *E. coli* 1.0 cfu/100ml, total heterotrophic bacteria 109 cfu/1ml, mould 27 cfu/1ml and 0.0 cfu/1ml for yeast. The specimen from mortar, also showed positive result for total coliform (6700 cfu/100ml), faecal coliform (1022 cfu/100ml) and *E. coli* (426 cfu/100ml), total heterotrophic (7100 cfu/1ml), mould (1404 cfu/1ml) and yeast (660 cfu/1ml). The specimen from pestle gave 7473 cfu/100ml for total coliform. The faecal coliform present was 489 cfu/100ml and *E. coli* was 394 cfu/100ml. Also, total heterotrophic bacteria, mould and yeast recorded 7709 cfu/1ml, 1598 cfu/1ml, and 955 cfu/1ml respectively. The "fufu" specimen from Chop Bar 'D' had 6832 cfu/100ml for total coliform. The faecal coliform present was also 41 cfu/100ml and 18 cfu/100ml for *E. coli*. The specimen also recorded total heterotrophic bacteria of 7857 cfu/1ml, mould of 720 cfu/1ml and yeast of 485 cfu/1ml. Specimens were also collected from the water used for turning "fufu" after the process was over. The results from Table 8 indicate that cfu/100ml for total coliform count was 4430; the faecal coliform obtained was 551 cfu/100ml and that of *E. coli* was 160 cfu/100ml. Total heterotrophic bacteria, mould and yeast recorded 5299 cfu/1ml, 689 cfu/1ml and 400 cfu/1ml respectively. Again, the results in Table 8 show that almost all the stages in the "fufu" preparation tested positive for the parameters in a descending order from total coliform, faecal coliform and *E. coli*. Table 8 further reveals that the result of total heterotrophic bacteria obtained from analyses of 1ml of test specimen of the parameter was positive in the entire specimen analysed and that it also had the highest recorded levels among the other parameters tested in the specimen. Results obtained from mould analyses in "fufu" production also depict that all but source of water used for pounding "fufu" tested positive with relatively high figures. The least load which was from source water recorded 27 cfu/1ml while

pestle recorded the highest load with 1598 cfu/1ml.

A critical look at the results of Tables 1 and 5 which represent most probable number and membrane filtration analysis for licensed Chop Bar 'A' respectively, depict that the specimen taken from the mortar recorded the highest values for almost all parameters by the membrane filtration analysis. For the most probable number results the specimen recorded a highest value for total coliform. That notwithstanding, the results revealed that specimen from mortar was the most contaminated followed by specimen from pestle. "Fufu", water for turning "fufu", and source water followed in that order. In all cases values far exceeded the permitted levels [32, 33]

Logically, it was expected that contamination would increase from source water through to "fufu" since micro-organisms continue to multiply in numbers once they fall on their substrates with all other favourable conditions present. However, this was not the case since the pattern of multiplication was not consistent along the path. For instance, specimens of water for turning "fufu" for both Tables 1 and 5 which dwelt on multiple tube fermentation analysis and membrane filtration respectively, were expected to have much higher counts considering the fact that the organisms present in mortar and pestle would influence the load in those specimen. The possible explanation that could be accorded the observed decreased load of total coliform in "fufu" and water for turning "fufu" is that the high temperature of the cooked staples might have killed some of the organisms in the mortar and pestle and hence the reduction of load observed in water for turning "fufu".

The high level of load in mortar specimen and specimen from pestle could have been influenced by the source water which might have been already contaminated with the organisms and was also used to wash the mortar and the pestle. The source of water used by Chop Bar 'A' was tap water and this was expected to have been treated water and therefore should not have harboured any biological contaminants. This notwithstanding, the presence of contaminants could not be totally ruled out since the containers used in fetching water and the sanitary condition of those who fetched the water could be possible sources of contamination. This presupposed that the water used for cleaning the mortar and pestle must be treated before use since it had the potential of introducing contaminants, thereby compromising the microbiological quality of the "fufu". The mortar itself should also be aired dry and covered since its wide surface area generally allows for the settlement and accumulation of microbiological contaminants through dust and other objects which drop into them. Insects such as flies, cockroaches and fleas from the animals used for food could also settle on both the mortar and the pestle. These insects visit unsanitary places and very often their bodies get contaminated.

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. While the count for total coliform generally followed a decreased pattern with one or two deviations, the result of the multiple tube filtration analysis (Table 1) followed an increased pattern of load for faecal coliform and *E. coli* but again with one or two deviations. 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. Specimen from pestle recorded the second highest load, followed by the "fufu" specimen with the specimen from mortar recording the least count for faecal coliform and *E. coli*. On the contrary, specimen from mortar recorded the highest load for faecal coliform and *E. coli* followed by specimen from pestle, then water for turning "fufu" with the "fufu" specimen recording the least load by the membrane filtration analysis. The possible assumption for the reduced load of the two parameters in the specimen from mortar (Table 1) could be the fact that the mortar was cleaned and stored hygienically, but this was not conclusive since load of the parameters in "fufu" was the highest and least in "fufu" specimen (Table 5).

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 results for specimen from pestle also suggested that the condition in which pestles were kept before using them to pound "fufu" accounted for sources of contamination.

Far-reaching reduction of mould levels of water for turning "fufu" and the "fufu" specimen (Table 5) could be attributed to the regular changing of the water during "fufu" pounding, and the high temperature of the "fufu". The high level of yeast contamination in the "fufu" specimen could be due to the yeast contamination from the mortar and pestle. The staples for preparing "fufu" contain starch and this can cause 'fufu" kept for a while before consumption to ferment and give rise to yeast in "fufu". Thus, all the stages in the "fufu" production process were contaminated with yeast. As a result, more yeast contamination was added to the food as it moved through the production stages. A similar study conducted on Compliance with food safety measures by traditional caterers

in the Cape Coast Metropolis published in International Journal of Home Economics indicated that levels of fungal species were not high in "fufu", which happened to be the most popular choice of clients, in the current study high levels of mould and yeast were recorded [9]. The discrepancy could have arisen from the methods of analysis used.

Results of the levels of microbiological contaminants at the various stages in the "fufu" production process of licensed Chop Bar 'B' (Tables 2 and 6) show that the mortar was a major source of bacteriological contamination. The level of contamination can be attributed to the exposure of the mortar to environmental agents before pounding "fufu". Also, washing mortar with contaminated hands is a probable cause of "fufu" contamination. In support of the contamination in the mortar, similar study on Sensory characteristics of "fufu" prepared with cassava roots (*Manihot Esculenta Crantz*) stored in polyethylene sacks indicated that direct human contact with the food preparation process is a significant source of microbiological contamination [34]. This revelation implies that microbiological contamination in the "fufu" of licensed Chop Bar 'B' could be reduced significantly if deliberate efforts are made to control them from the mortar.

The trend of load of contaminants recorded for specimen from licensed Chop Bar 'B' reveals that the pattern of load was not the same for the two analytical methods (Tables 2 and 6). While the source of water registered the least load (45 MPN/100ml and increased to 1339 MPN/100ml at the end of the process for multiple tube fermentation analysis, the load of source of water decreased at the end of the process with the membrane filtration analysis although the difference was marginal. 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 specimen. The results portrayed in Table 3 and 7 show that while total coliform contamination was highest in the mortar for the membrane filtration analysis it was the "fufu" specimen that registered the highest in the same parameter in the case of the multiple tube analysis. The condition in which the mortar and pestle were kept could have accounted for the level of contaminants recorded. The mortar and pestle were exposed to all manner of environmental contaminants including flies. The inner part of the mortar was also not a levelled ground so left-over "fufu" was seen in the wedges. Food contamination incidences are as a result of poor storage of cooking utensils and raw materials including mishandling such as keeping food at the wrong temperature [35].

Moreover, the level of total coliform in specimen from mortar and pestle for the multiple tube fermentation (Table 2) together might have influenced the load evidenced in the "fufu" specimen contrary to expectation. The common knowledge and expectation was that there would be a decreased load of total coliform in the "fufu" because of the high temperature of the staples as was the case in the pattern of faecal coliform load. The high load of total coliform in the "fufu" is suggestive of the fact that the staples might have been left to cool before pounding and no hand washing procedure was followed by caterers. The organisms therefore could have been transferred from food handlers, water used and the equipment for food processing while reduction of faecal coliform contaminants in the "fufu" specimen (67 MPN/100ml) could be due to 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 membrane filtration analysis (Table 6) however met the common expectation of decreased load of all parameters in the "fufu" specimen with the total heterotrophic bacteria

Microbiological analyses in non-licensed Chop Bar 'C' (Tables 3 and 7) show that while specimen from the mortar were the most contaminated by the multiple tube fermentation analysis the pestle was the case by the membrane filtration analysis. The result of the membrane filtration analysis for Chop Bar 'C' (Table 7) also shows that the microbiological load in the "fufu" specimen was relatively lower than the other stages, especially specimen from the mortar and pestle. This was attributed to the boiling of the staples before pounding the "fufu", as well as the rinsing of the mortar and pestle with relatively clean water before pounding "fufu". Comparison of the level of load for source water and the water for turning "fufu" for membrane filtration analysis (Table 7) and multiple tube fermentation analysis (Table 3) indicates marked differences between each pair of values for total coliform. The picture portrayed by other parameters was not that different. That notwithstanding, the difference in the level of total coliform contaminants in the source water and water used for turning "fufu" (Tables 3 and 7) suggests that more total coliform from the mortar and pestle were introduced into the water used for turning "fufu" during pounding considering the values of the former. The water source was from well and the presence of total coliform presupposes that the water was not clean enough. It was also observed that the untreated water was used to rinse the mortar and pestle.

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, bacterial contamination of drinking water sources at Mpraeso, Ghana, showed that groundwater sources are as polluted as surface water sources [21]. For this reason however, it is important that groundwater undergoes treatment before usage. For instance,

chop bar operators who use well water may 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 specimen 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°C, where micro-organisms thrive and multiply at a rapid rate hence, the unacceptable levels of microbial load.

A look at Tables 4 and 8, which present the results of both multiple tube fermentation and membrane filtration analysis for non-licensed 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 micro-organisms into the pipe borne water.

In the case of the multiple tube fermentation analysis, the presence of high level of the parameter as well as other parameters in specimen mortar and pestle could have accounted for the increased level of load in "fufu". The apparent relatively small load of total coliform in sample water for turning "fufu" could be as a result of the fact that the operator changed the water for turning "fufu" frequently (Table 4). The high levels of faecal coliform and *E. coli* in the multiple tube fermentation analysis (Table 5) is not matched by the membrane filtration results (Table 8). 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" specimen 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 [9].

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. Temperature regulation at the various stages in food production is critical for achieving total food quality [36]. Findings on effect of sand and sawdust bedding materials on the faecal prevalence of *Escherichia coli* O157: H7 in dairy cows, also add that *E. coli* is easily killed by heating [37]. These assertions also agree with the third principle of the HACCP food safety approach, posits that there should be established preventive measures, such as temperature control to manage critical limits at each critical point in the food preparation process [32]. 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 the 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 specimen. The latter analytical method on the other hand just estimates the load of organisms that may be present in the specimen which may not always give the true picture of what is present in the specimen, hence the disparity [38].

An adjusted R Square value of 0.755 implies that 75.5% of changes in the microbiological parameters of "fufu" specimen were explained by the microbiological parameters in the other stages (source of water, specimen from the mortar, specimen from the pestle, and water for turning "fufu"). This implies that other variables explain 24.5% of variations in the microbiological parameters of "fufu" specimen, 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" specimen. Thus, the Sig value of 0.001 was within the acceptable error margin value of 0.05.

However, the study further examined the contribution of the microbiological parameters in each of the stages in "fufu" production process to variations in the microbiological parameters in "fufu" specimen. This was necessary to assess how changes in the microbiological parameters at one stage

of the production would affect the microbiological parameters of "fufu". It was also imperative to inform the Cape Coast Metropolitan Assembly, Ghana Standards Authority, and the Foods and Drug's Board on areas they should direct their campaign to ensure total food quality from chop bars.

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", while the other stages such as the mortar and pestle retain part of the microbiological parameters through the cracks, surfaces and the fibrous end of the pestle.

Also, Comparing the p-value of 0.016 with the acceptable error margin of 0.05 implies that the effect of microbiological parameters from the pestle on the microbiological parameters in "fufu" was statistically significant. This agrees with the HACCP principle that the level of microbiological parameters of food is a function of the level of microbiological parameters at the various stages in the production process.

Once again, Comparing the p-value of 0.960 with the acceptable error margin of 0.05 implies that the effect of the microbiological parameters in the sample from the mortar on the microbiological parameters of "fufu" from the selected chop bars was not statistically significant. This means that efforts to eliminate microbiological parameters from "fufu" should focus on avoiding microbiological parameters in the water used for turning "fufu", protecting pestles from microbiological contaminants, as well as controlling possible contaminants in such areas from entering the food. Constructing regression equation for the possible sources of microbiological parameters in "fufu" 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 (specimen from the mortar) + 0.390 (specimen from the pestle) + 0.491 (water used for turning "fufu").

5. Conclusions and Recommendation

The study concluded that there is high amount of contaminated "fufu" being sold and consumed in Cape Coast. Source water for pounding "fufu", specimen from the mortar and pestle, and water for turning "fufu" (which was the most significant) were found to be the possible sources of contamination of "fufu" produced in chop bars in the Cape Coast Metropolis. Major practices such as the use of untreated water to turn "fufu", improper washing of mortar and pestle, and improper washing of hands before pounding and turning "fufu" contributed significantly to the unwholesomeness of "fufu". Based on the conclusions of the study, for non-microbial contamination in "Fufu", it is recommended that licensed and non-licensed traditional catering or Chop bar operators should strictly observe personal, food and kitchen hygienic practices to ensure that "fufu" produced from their outfits are rid of microbial parameters.

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