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Research Paper

Enumerated Bacteria on Cooked Food Samples in Some Hotels in Kumasi in the Ashanti Region of Ghana

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Abstract: *Kumasi is the capital of the Ashanti Region of Ghana and also the second largest city. Kumasi was selected for this study because out of 27,000 cholera cases in Ghana, Kumasi was one of the most affected. Levels of microbial counts on some cooked food samples in some selected hotels in Kumasi, the Ashanti Region of Ghana were determined. The hotels were selected by simple random sampling and ranged from three star to budget. Serial dilution of each food was prepared in buffered peptone water inoculated onto Plate Count Agar (PCA) for total mesophilic count, MacConkey Agar (MCA) for total coliform count and Violet Red Bile Glucose Agar (VRBGA) for total enterobacteriaceae count. Growth was counted and the bacterial counts were expressed to log_{10} cfu/g. The agar with the highest colony count for Hotel 01 was MacConkey and the food with the highest number of bacteria was fufu (7.0 Log_{10} cfu/g). Hotel 02 had PCA and MCA reporting the highest microbial count for beef in vegetable sauce (6.8 Log_{10} cfu/g). In Hotel 03 tossed salad and fried rice were too numerous to count (TNTC) for all the media used. Hotel 04 reported boiled plain rice to be the food with the highest (6.5 Log_{10} cfu/g) colony count on PCA. Vegetable sauce on MCA had the highest colony counts (7.2 Log_{10} cfu/g) for Hotel 05. Most of the colony counts were above the WHO acceptable levels of <3 log $_{10}$ cfu/g indicating levels of contamination in the foods tested.*

Keywords: Food handlers, food safety, hotels, colony counts, contamination.

1. Introduction

Food borne diseases have prevailed over the past few decades as a worldwide challenge with a high percentage of food borne disease outbreaks associated with different areas of the food service industry (Cavalli and Salay, 2004; Todd, 2003; Sheppard *et al*., 1990). Studies on foodborne disease (FBD) outbreaks show that eating food prepared in restaurants is an important source of infection (Angulo and Jones, 2006). In food service environments, various factors may be related to FBDs. According to European Food Safety Agency (EFSA) (2010), the major risk factors causing FBDs include foods from unsafe source, inadequate cooking, improper holding temperatures, contaminated equipment and poor personal hygiene.

Approximately 2.2 million deaths caused by diarrhoeal disease are recorded annually worldwide and most of these cases are attributed to contaminated food and water (WHO, 2002). Developing countries, however, bear the brunt of the problem due to the presence of a wide range of foodborne diseases including those caused by parasites (Salas, 2011). Again, developing countries suffer despite important developments in reducing the incidence of certain pathogens in foods through better farm practices and food regulations (Scott, 2003).

A lot of work has been done on the safety of street foods in most developing countries, yet not much has been done with regards to the hotel industry in Ghana (Addo *et al*., 2007). Again, it is perceived that the higher the star rating of a hotel, the safer the food but studies conducted shows some contamination in food from hotels (Annor and Baiden, 2011; Sabbag and Hepsag, 2011). In Ghana, the extrapolated incidence of food poisoning is estimated to be 5.8 million annually (Salas, 2011). The high prevalence of diarrhoeal diseases in many developing countries suggests major underlying food safety problems (WHO, 2007). Mishandling of food plays a significant role in the occurrence of foodborne illnesses. For instance, improper food handling is implicated in 97% of all food borne illnesses associated with catering outlets with Africa contributing 90% of cholera cases globally (Addo *et al*., 2007). Ghana accounted for 27,000 of these cases with Kumasi in the Ashanti Region being the most affected (Ababio and Addy, 2012). Similarly, poor food-handling practices were implicated to be the major cause of outbreaks of infectious intestinal diseases (IID) in England and Wales according to Egan *et al*. (2007). These data suggest a critical need for action that is focused on preventing disease transmission within the hotel industry (Angulo and Jones, 2006). The study aimed to find out the possible microbial load in foods from hotels in the Kumasi metropolis of Ghana.

2. Materials and Methods

2.1 Research Location

The study was undertaken at five hotels in the Kumasi metropolis in the Ashanti Region of Ghana. The hotels selected ranged from “three star to budget” and have intense patronage throughout the year.

2.2 Ethical Consideration

The data was collected after a written informed consent was obtained from all the Managers and study participants (food handlers of the hotels) and the study approved by the Committee for Human Research and Ethics (CHRE) at the School of Medical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

2.3 Sample Collection

Samples of cooked food were aseptically collected in two batches from five hotels only between 12:00 mid-day and 1:00 pm each day with four foods in each batch. The foods were collected in the

restaurant at the point of serving. The cooked food samples were kept in sterile stomacher bags (Sharpe and Jackson, 2000) and immediately stored inside an ice chest with ice packs while transporting them to the laboratory for analysis within two hours of collection. The foods collected were those that were available for the day and samples were examined the same day.

2.4 Determination of Microbial Count on Food Samples

Microbial count on the collected food samples from the hotels' kitchens were determined based on the method described by Herrera (2002). The samples were assessed for total coliform, total aerobic mesophiles (TAMC) and enterobacteriaceae.

2.4.1 Homogenization of Food Sample

Ten gram of food sample was weighed into a stomacher bag as representative of the whole samples. Ninety milliliters of sterilized bacteriological peptone water (Oxoid LP0037 USA) was added to the sample, making a dilution of 1:10. This was then agitated vigorously for 2 min and 50 ml of the liquid was transferred, after foam has dispersed, with a sterile pipette onto a sterile 50 ml centrifuge tube.

2.4.2 Serial Dilution

One millilitre (1000 µl) of the sample from the 50 ml (10^{-1}) was pipette into a separate tube containing 9 ml of peptone water; the fluid in the test tube would now contain 10 ml, which are 1:100 dilutions (10^{-2}). The liquids were carefully mixed by aspirating 10 times with a sterile pipette and again transferred with the same pipette 1.0 ml to another dilution tube containing 9 ml of dilution fluid and mixed with a fresh pipette to obtain a 10^{-3} dilution. The above procedure was repeated to obtain a final dilution of 10^{-6}. Each successive dilution decreased the concentration 10-fold.

2.4.3 Spread Plate

For each of the dilutions, 0.1 ml (100 µl), was transferred to the surfaces of the following agar; using sterile glass spreader (Drigalsky spatulas) (Herrera, 2002). Mac Conkey Agar (Sigma M8302) for coliform, Plate Count Agar (70172 (Fluka Anajytical) for aerobic plate count, Violet Red Bile Glucose Agar (Oxoid LP0037) for enterobacteriaceae in triplicate using separate pipette for each dilution. The dilution (0.1 ml) was promptly spread on the surface of the agar plates. A separate spreader was used for each plate and the surface of each plate was allowed to dry for 15 min. The plates were then incubated in an inverted position for 72 h at 30 ^{o}C.

2.4.4 Bacteria Counts

The three plates corresponding to one dilution were counted using the colony counter. All colonies in three plates corresponding to one dilution and showing between 20-200 colonies were counted. Averages of the replicates were calculated and multiplied by their dilution factor. This was then reported as the colony forming unit per gram. Overcrowded colonies were not counted and were reported as "Too Numerous To Count" (TNTC).

2.5 Data Analysis

One way Analysis of Variance (ANOVA) was performed and the values obtained for cfu/g of food were converted to $\log_{10}$ values. Foods were classified as having no-to-low risk of transmitting pathogenic bacteria if the total count was < 3.0 $\log_{10}$ cfu/g (WHO, 1999).

3. Results and Discussion

3.1 Colony Count of Bacteria Growth on Foods from Hotel 01

From Table 1(Hotel 01) the microbial count for Total Mesophilic Count (TMC) ranged from 2.0 Log_{10} cfu/g to 6.7 Log_{10} cfu/g while colony count on Total Coliform Count (TCC) ranged from 2.0 Log_{10} cfu/gto 7.0 Log_{10} cfu/g. The count on Total Enterobacteriaceae Count (TEC) ranged between 2.0 Log_{10} cfu/g and 6.4 Log_{10} cfu/g. The foods with the highest count on TMC were fresh pepper sauce (6.7 Log_{10} cfu/g) and fufu (6.7 Log_{10} cfu/g), that on TCC was fufu (7.0 Log_{10} cfu/g) and the highest on TEC also being fufu (6.4 Log_{10} cfu/g).

Table 1: Bacterial counts on foods from Hotel-01

FOOD	COLONY COUNT (cfu/g)					
	TMC	Log	TCC	Log	TEC	Log
Chicken and vegetable sauce	$1.0x10^2$	2.0	NOG	-	NOG	-
Beef sauce	$2.7x10^2$	2.4	$1.0x10^2$	2.0	$1.0x10^2$	2.0
Goat light soup	$2.7x10^4$	4.4	$7.3x10^3$	3.9	$5.4x10^3$	3.7
Tossed mixed vegetable	$3.3x10^4$	4.5	$1.7x10^4$	4.2	$3.7x10^2$	2.6
Boiled plain rice	$1.1x10^5$	5.0	$6.7x10^4$	4.8	$1.0x10^4$	4.0
Fresh pepper sauce	$4.5x10^6$	6.7	$1.3x10^4$	4.1	$1.7x10^4$	4.2
Fufu	$5.5x10^6$	6.7	$1.1x10^7$	7.0	$2.3x10^6$	6.4

TMC = Total Mesophilic Count; TCC = Total Coliform Count; TEC = Total Enterobactriaceae Count; NOG = No Observable Growth

3.2 Colony Count of Bacteria Growth on Foods from Hotel 02

Colony count on TMC from Table 2 (Hotel 02) ranged from 4.6 Log_{10} cfu/g to 6.8 Log_{10} cfu/g whiles that on TCC ranged from 4.3 Log_{10} cfu/g to 6.8 Log_{10} cfu/g. The food with the lowest count on TEC was fried rice (3.0 Log_{10} cfu/g) and the highest was braised rice (7 Log_{10} cfu/g). All the foods were above the WHO acceptable limits of < 3.0 log_{10} cfu/g.

Table 2: Bacterial counts on foods from Hotel-02

FOOD	COLONY COUNT (cfu/g)					
	TMC	Log	TCC	Log	TEC	Log
Fried rice	$3.7x10^4$	4.6	$2.2x10^4$	4.3	$9.3x10^3$	3.0
Potato chips	$4.5x10^5$	5.7	$5.7x10^6$	6.8	$1.7x10^5$	5.2
Jollof rice	$4.4x10^6$	6.6	$2.6x10^6$	6.4	$4.2x10^6$	6.6
Coleslaw	$4.7x10^6$	6.7	$4.6x10^6$	6.7	$4.2x10^6$	6.6
Grilled steak	$5.6x10^6$	6.7	$5.5x10^6$	6.7	$1.2x10^6$	6.1
Beef in vegetable sauce	$6.2x10^6$	6.8	$4.7x10^6$	6.8	$6.9x10^5$	5.8
Chicken with noodles and vegetables	$9.3x10^6$	6.0	$2.2x10^6$	6.3	$3.7x10^4$	4.6
Braised rice	$9.6x10^6$	6.0	$5.4x10^6$	6.7	$5.1x10^6$	6.7

TMC = Total Mesophilic Count; TCC = Total Coliform Count; TEC = Total Enterobactriaceae Count; NOG = No Observable Growth

3.3 Colony Count of Bacteria Growth on Foods from Hotel 03

The colony count on TMC from Table 3 (Hotel 03) ranged from 3.5 Log_{10} cfu/g to 4.6 Log_{10} cfu/g while that on TCC ranged from 2.4 Log_{10} cfu/g to 4.5 Log_{10} cfu/g and on TECwas from 3.0 Log_{10} cfu/g to 4.2 Log_{10} cfu/g. Beef sauce recorded the highest count on both TMC and TCC but there was no observable count on TEC. Other foods with no observable count on TEC were beef sauce, tossed mixed vegetables and tomato sauce.

Table 3: Bacterial counts on foods from Hotel-03

Food	COLONY COUNT (cfu/g)					
	TMC	Log	TCC	Log	TEC	Log
Tossed salad	TNTC	-	TNTC	-	TNTC	-
Fried rice	TNTC	-	TNTC	-	TNTC	-
Boiled plain rice	$3.0x10^3$	3.5	$2.7x10^2$	2.4	NOG	-
Fish light soup	$3.7x10^3$	3.6	$8.0x10^2$	2.9	$1.0x10^3$	3.0
Fried fish	$4.3x10^3$	3.6	$1.7x10^3$	3.2	$1.7x10^4$	4.2
Tossed mixed vegetable	$1.0x10^4$	4.0	$2.0x10^3$	3.3	NOG	-
Tomato sauce	$2.3x10^4$	4.4	$1.3x10^4$	4.1	NOG	-
Beef sauce	$4.3x10^4$	4.6	$3.0x10^4$	4.5	NOG	-

TMC = Total Mesophilic Count; TCC = Total Coliform Count; TEC = Total Enterobactriaceae Count; NOG = No Observable Growth; TNTC = Too Numerous To Count

3.4 Colony Count of Bacteria Growth on Foods from Hotel 04

Colony count on TMC, TCC and TEC ranged from 3.0 Log_{10} cfu/g to 6.5 Log_{10} cfu/g, 3.1 Log_{10} cfu/g to 6.4 Log_{10} cfu/g and 3.1 Log_{10} cfu/g to 6.3 Log_{10} cfu/g respectively (Table 4). Boiled plain rice recorded the highest on both TMC and TCC while mixed salad recorded the highest on TEC. Jollof rice recorded no observable growth on TCC and TEC. Vegetable sauce and beef sauce also recorded no growth on TEC**.**

Table 4: Bacterial counts on foods from Hotel-04

Food	COLONY COUNT (cfu/g)					
	TMC	Log	TCC	Log	TEC	Log
Vegetable sauce	$1.0x10^3$	3.0	$1.4x10^3$	3.1	NOG	-
Jollof rice	$4.7x10^3$	3.7	NOG	-	NOG	-
Fried rice	$2.4x10^4$	4.4	$1.8x10^4$	4.3	$1.4x10^3$	3.1
Beef sauce	$2.7x10^5$	5.4	$2.6x10^3$	3.4	NOG	-
Fried chicken	$1.3x10^6$	6.1	$1.0x10^5$	5.0	$7.0x10^4$	4.8
Mixed salad	$2.8x10^6$	6.4	$8.7x10^5$	5.9	$1.8x10^6$	6.3
Boiled plain rice	$3.3x10^6$	6.5	$2.6x10^6$	6.4	$7.3x10^5$	5.9

TMC = Total Mesophilic Count; TCC = Total Coliform Count; TEC = Total Enterobactriaceae Count; NOG = No Observable Growth

3.5 Colony Count of Bacteria Growth on Foods from Hotel 05

Table 5 shows the colony count on foods from Hotel 05. The colony count on TMC ranged from 3.2 Log_{10} cfu/g to 6.9 Log_{10} cfu/g while on TCC the colony count was between 3.1 Log_{10} cfu/g and 7.2 Log_{10} cfu/g. The colony count on TEC ranged from 2.1 Log_{10} cfu/g to 6.8 Log_{10} cfu/g. Vegetable

sauces had the highest colony count on TMC, TCC and TEC. There was no observable growth from jollof rice on TMC and TEC.

Table 5: Bacterial counts on foods from Hotel-05

Food	COLONY COUNT (cfu/g)					
	TMC	**Log**	**TCC**	**Log**	**TEC**	**Log**
Jollof rice	$1.7x10^3$	3.2	NOG	-	NOG	-
Boiled fish	$5.3x10^4$	4.7	$1.2x10^3$	3.1	$1.3x10^2$	2.1
Fried chicken	$1.6x10^5$	5.2	$2.6x10^3$	3.4	$1.3x10^3$	3.2
Mixed vegetable salad	$2.3x10^5$	5.4	$2.7x10^6$	6.4	$2.3x10^5$	5.4
Boiled plain rice	$6.2x10^5$	5.8	$2.7x10^4$	4.4	$5.9x10^5$	5.8
Fried rice	$7.0x10^5$	5.8	$4.0x10^4$	4.6	$4.7x10^3$	3.7
Goat light soup	$2.9x10^6$	6.5	$1.7x10^4$	4.2	$4.1x10^5$	5.6
Vegetable sauce	$8.2x10^6$	6.9	$1.5x10^7$	7.2	$5.9x10^6$	6.8

TMC = Total Mesophilic Count; TCC = Total Coliform Count; TEC = Total Enterobactriaceae Count; NOG = No Observable Growth

3.6 Boiled Plain Rice, Jollof Rice and Fried Rice

Boiled plain rice in Hotel 01 which is a high class hotel (3 star) had high colony count (Table 01). The colony count on Hotel 03 which is a two-star hotel was comparatively better (Table 03). There were higher counts in hotels 04 and 05 (Table 04 and Table 05). The results are in contrast with the findings of Mensah *et al*. (2007) where rice samples collected from some hotels in Accra were within acceptable limits. On the other hand, other studies conducted by Mensah *et al* (2002) on microbial qualities of foods sold on streets of Accra where a large proportion of dishes including rice were heavily contaminated confirm the results of this study. Wogu *et al*. (2011) also isolated four bacteria from boiled rice namely; *Bacillus cereus, Staphylococcus aureus, Escherichia coli* and *Klebsiella pneumonia.*

Fried rice from Hotel 02 in this study was also above the acceptable limit (Table 2). Hotel 03 (Table 3) which is rated two-star had colony count on fried rice which was too numerous to count. Hotel 04 (Table 4) which is one-star rated recorded colony counts above the acceptable limits. Hotel 05, a budget hotel, had unacceptable levels of colony counts (Table 5). Wogu *et al*. (2011) in their studies to determine microbial load in ready-to-eat rice sold in Benin City also found microorganism in fried rice in comparison to other rice preparations. The result is also similar to that reported by Patricia and Azanza (2005) who determined Aerobic Plate Counts of Philippines ready-to-eat foods from take-away premises. The prolong handling of fried rice during cooking in Ghana and addition of spices could have contributed to the contamination.

In Hotel 04 (Table 4) jollof rice had colony count of 3.7 $\log_{10}$ cfu/g on PCA and no observable growth on MCA and VRBGA. Also in Hotel 05 (Table 5) which is a budget hotel, the count was high on only PCA and no observable growth on MCA and VRBGA. This is in contrast with studies conducted by Wogu *et al*. (2011) where jollof rice collected from two standard restaurants in Benin City had the lowest microbial load for bacteria. In this study only Hotel 02 (Table 2) recorded significantly high levels of colony counts in jollof rice despite being a three-star rated. Perhaps this difference could be attributed to the type of rice and sanity of the serving dishes used by the different hotels. Rice may become contaminated during growth, harvesting and other agricultural operations such as processing and handling (Haque and Russel, 2005). The rice can contain bacteria that may survive the cooking process. For instance *Bacillus cereus* is present in rice as spores until water is added then they start to grow. Since the cooking will not kill most resistant spores, it is better to keep the cooked rice at temperature of 60 ^oC to 70 ^oC and should also not be kept for more than 4 days in the refrigerator.

Rice is prepared everyday in this hotel and therefore the needed precaution such as checking for foreign bodies and thorough washing before cooking may have been taken for granted and hence the contamination. Again, the contamination may have come from the serving spoon which may not have been wiped properly with a clean napkin. The microbiological contamination of the rice may also be caused by poor personal hygiene of food handlers and incorrect holding temperature. Perhaps the microorganism may have originated from the natural microflora of the rice which in most cases may have no discernible effect and the rice may be consumed without objection (Adams and Moss, 2000).

3.7 Tossed Mixed Vegetable, Fresh Pepper Sauce, Coleslaw, Tossed Salad, Tossed Mixed Vegetable, Mixed Salad and Mixed Vegetable Salad

All the salads and other raw vegetable preparations were above the acceptable limits except tossed mixed vegetables on VRBGA in Hotels 01 (Table 1) and Hotel 03 (Table 3). Fresh pepper sauce in Hotel 01 had high colony count (Table 1) probably because of the way it is prepared. This result is in line with previous studies conducted by Feglo and Sakyi, (2012) who found contamination in fresh pepper sauce from street vending foods in Kumasi. In a normal traditional Ghanaian way, fresh pepper sauce is made from fresh pepper, fresh tomatoes and onions which is blend in an earthenware bowl and a wooden masher and eaten without heating. Thus all bacteria introduced at the time of preparation survive and multiply if held for too long at ambient temperatures (Ghana Standards Authority, 2003). In this particular hotel the fresh pepper sauce was prepared in a blender and if the same blender is used in blending other foods, it could have accumulated bacterium and can introduce contamination into the pepper. Other factors could be insufficient washing, poor storage and talking during preparation.

All the salads in the hotels as seen in Tables 1-5 had higher colony counts. The cause may have been improper washing of the vegetables used since on the farm, sewage, sludge, manure and compost of animal and human origin are commonly used as organic fertilizer (FDA, 2006). Gloves were worn by the cooks during the preparation of the salad but from observation they were never changed during the entire process. Previous studies carried out by Yeboah-Manu *et al*. (2010) in Accra also found salad to be above the acceptable limits. The ingredients throughout the preparation stage might not have been kept as cold as possible to inhibit microbial contamination. The cause may also be due to cross-contamination from chopping boards if they are not washed properly before vegetables are cut on them. The salads in this study were mixed with salad cream which contains egg yolk and Ameko *et al*. (2012) found that this could possibly be a medium for supporting microbial growth. The annual report of Ghana Health Services (2007) reported of school children who were fed with salad among other things and developed gastroenteritis.

3.8 Chicken and Vegetable Sauce, Chicken with Noodles and Vegetables, Fried Chicken

All the chicken dishes, which are referred to as the main dish in the catering industry, exceeded the acceptable limits except Hotel 01 (Table 01). The colony counts were 2.4 $\log_{10}$ cfu/g on PCA, 2.0 $\log_{10}$ cfu/g on MCA and 2.0 $\log_{10}$ cfu/g on VRBGA. This is a three-star hotel where good quality food is expected by the general public. Perhaps the method of cooking and temperature control may have contributed to the high level of colony counts.

Hotel 02 (Table 2) had high colony counts on PCA, MCA and VRBGA despite being a three star hotel and several causes may be attributed to the high counts. Hotels 04 and 05 also exceeded the acceptable levels as shown in Tables 4 and 5. The high colony counts could be accounted for the rich nature of chicken which can create a condition for growth of microorganisms. Chicken which is high in protein and very susceptible to bacteria is cooked before cutting and mix with cooked noodles and vegetables and this handling could promote bacteria growth. Inadequate hand washing coupled with poor personal hygiene could contribute to the contamination. Throughout the preparation time,

bacteria from the preparation environment could possibly contaminate the food (Todd *et al*., 2009). If during the preparation some of the cooks were infected, the food can possibly be contaminated.
The results in this study is in contrast with that obtained from some hotels in Accra by Addo *et al*. (2007) where chicken sampled negative for total aerobic count, coliform and enterobacteriaceae. Chicken is vulnerable to contamination especially *Salmonella* and *Campylobacter* organisms during processing such as defeathering and evisceration (Mariott and Gravani, 2006). Unsanitary food handling such as, not having separate knives and cutting boards for raw meat as well as inappropriate storage temperature can further contaminate the chicken. Again proper cleaning and sanitizing procedure was not seen in these kitchens and unsanitized serving dishes can easily contaminate the fried chicken.

3.9 Beef Sauces, Grilled Steak and Goat Light Soup

Beef sauce was also within the acceptable limits in Hotel 01 (Table 1). Perhaps the methods of cooking these sauces may have contributed to their acceptable levels. The preparation of beef sauce in Ghana involves long cooking of the cut beef until tender and then added to tomato sauce and allowed to cook again. Beef also falls within the potentially hazardous foods because of the high protein content. This thorough cooking may destroy most harmful bacteria and make it safe to eat as emphasized by DOH (2010).Mensah *et al*. (2002) who reported on microbiological quality of different types of foods (including meat stew) collected from hotels in Accra, Ghana, found no growth of *Staphylococcus aureus, Salmonella* and *E. coli*. In contrast, the colony count for goat light soup was above the acceptable limits for PCA, MCA and VRBGA in Hotel 01 and 05 (Table 1 and 5) despite the long boiling time used for goat light soup. This is not surprising because other ingredients like ginger, aniseed and garlic are normally added to spice the meat and are potential vehicles of microorganisms and toxins (Mariott and Gravani, 2006). Mensah *et al*. (2002) in their studies found soup to be more contaminated with enteroaggregative *E. coli*. The goat meat may also have been contaminated during slaughtering and poor preparation procedure may have also contributed to the contaminated soup.

Grilled steak from Hotel 02 (Table 2) is prepared from lean sliced beef, seasoned with spices and cooked under the grill. The meat may have been contaminated from the slaughter house (Jay, 2000). If the grilling is not done thoroughly the middle of the meat will become undercooked and may not kill the most heat resistant spores which may result in contamination. The grilling which is done outside the kitchen could be contaminated with air-borne microorganisms from the environment as well as the metal bars on the grill which if not cleaned properly may also introduce organisms onto the grilled meat and cause contamination. The vegetables in this food could also be a source of contamination if not cooked properly.

Beef sauces in Hotels 02, 03 and 04 (Tables 2, 3 and 4) were also above the acceptable limits. Probably, the beef was contaminated at the time of purchase coupled with wrong and prolonged storage temperature in the hotels. Within the beef slaughter and dressing process, carcass skinning and evisceration process have been identified as probable introduction point of major contamination (Adams and Moss, 2008; Mariott and Gravani, 2006). Contact between carcass and hide allows a mixture of microorganisms to be introduced onto the carcass. These microorganisms may be of faecal, soil, water or feed origin and also process workers and the processing environment (Kwaasi, 2003). This initial quality of beef if not handled properly, may affect the final microbiological quality of the food.

3.10 Fish Light Soup, Fried Fish and Boiled Fish

Fish light soup had high colony count on only PCA and low count on MCA and VRBGA in Hotel 03 (Table 3). The long boiling period of the soup may be a contributing factor to the low count on MCA and VRBGA. Fried fish also had high colony count in Hotel 03 (Table 3) and boiled fish was within the acceptable count on VRBGA and above the acceptable limit on PCA and MCA. The

contamination of boiled fish is surprising since it involves a long boiling process. Contamination may have come from the water used in the soup preparation since water is one of the major ingredients in soup preparation. If raw sewage which contains pathogens from human and other materials from the environment flow into potable water through faulty plumbing, that water may contain microorganisms and can cause typhoid and paratyphoid fever. The contamination may also have come from airborne microorganisms from the unclean air present in the kitchen which may gain access due to uncovered pot.

Fish can be easily contaminated by human pathogens especially during its storage and handling. The high colony count could perhaps be attributed to the poor ventilation of the kitchen resulting in warm environment and direct contact on the fish with bare hands during cooking as well as high temperature exerted on the fish over a long period. The contamination may also come from the sauce of supply. Rajasinghe and Rajakaru (2005) found in their studies in Sri Lanka that the conditions of 50 % of fish stalls were not within the stipulated standards. Also, fishes that live in polluted water with human and animal faecal matter may carry substantial number of bacteria which may contaminate food (Rajasinghe and Rajakaru, 2005).

Mensah *et al*. (2002) found that fish can be an additional source of pathogens. The high colony count on fried fish in this study may probably be due to excessive handling of the fish during cleaning prior to frying which is a normal practice in Ghana. Kwaasi (2003) also confirmed in his study on microorganisms that fish can be easily contaminated by human pathogens during handling. The handling in the kitchen involves the removal of scales, gills, fins and the gut with a knife and the bare hands. The hands may not be washed before this operation and can possibly contaminate the fish. Kwaasi (2003) again added that the skin, gills and alimentary track carry large numbers of bacteria and can be as high as 10^7 on the skin and up to 10^9 in gills and in the gut and these are mainly Gram-negative of the genera *Pseudomonas, Shewanella, Psychrobacter, Vibtio, Flavobacterium* and *Cytophaga* as well as a few gram positive including *Micrococci* and *Coryneforms*. To save money, oil for frying are not changed regularly and could possibly contaminate the fish. Contamination could also come from wholesalers hands during packaging.

3.11 Fufu

The colony count for fufu in Hotel 01 (Table 1) was 6.7 $\log_{10,}$ 7.0 $\log_{10}$ and 6.4 on PCA, MCA and VRBGA respectively. Fufu is a Ghanaian traditional food which is prepared by excessive handling after cooking with the bare hands which are washed occasionally in a bowl of water. Pathogens can easily be transmitted into the fufu by the food handler's hands (Todd *et al*., 2007). The organisms will multiply if the fufu is not eaten immediately. There should be a thorough hand washing which is the first line of defence against bacteria, before preparing the fufu. The use of bare hands in preparing the fufu can still be a problem because one of the easiest ways to spread bacteria is through dirt under the fingernails (Mariott and Gravani, 2006). Normally untrained persons are employed to pound the fufu without hair cover and can lead to hair fallen into the fufu unnoticed. Mariott and Gravani (2006) add that microorganisms especially Staphylococci are found on hair and may easily contaminate the fufu. A study by Mensah *et al*. (2002) and Feglo and Sakyi (2012) found unacceptable levels of bacteria in fufu. This is a three star hotel where foods prepared are expected to be of highest microbiological standards.

4. Conclusion

It can be said that most of the foods were above the acceptable limits due to preventable reasons. It is not only foods from lower hotels that are likely to be contaminated but foods from top hotels are also possible. The higher colony count on the foods in this study is alarming and as such similar studies should be conducted in more hotels in Kumasi and the results compared. There should be a policy whereby the Ghana Standard Authority and the Ghana Tourism Authority will include food sample test in their future inspection as well as better application of HACCP principles in the hotels.

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