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Bacteriological Quality of Ready-to-Eat Foods Sold on and Around University of Ghana Campus

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Abstract: The aim of this study was to determine the microbial quality of ready-to-eat foods being sold in the open (street foods) and those from restaurants on the university of Ghana campus. A total of 27 foods were sampled from the 5 sites. Four microbiological parameters, namely Aerobic Colony Count (ACC), total Enterobactereacea (EC), presence of *Escherichia* coli and other Enterobacteriaceae and the presence of *Salmonella* sp. and *Shigella* sp. were used. Forty eight percent (13/27) of the foods sold had ACC values within acceptable limits, that is $<10^4$ cfu g^{-1} whiles 52% (14/27) had ACC values above acceptable limits and therefore, unsatisfactory for consumption, 59.3% had EC values within the acceptable limits whiles 40.7% had EC above the limit. Nine different bacterial species were isolated from the foods sampled. These were *E. coli*, *Klebsiella pneumoniae*, *Streptococcus* sp., *Enterobacter cloacae*, *Bacillus* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus* sp., *Streptococcus agalactiae* and *Enterococcus faecalis*. On comparing the microbial qualities from the two sectors we found no difference in their microbiological qualities using student's t-test analysis (t-test< t-value: 0.397<2.06). The level of microbial contamination in some food samples both the open market and restaurants were above the acceptable limits. Therefore, present findings call for a more stringent supervision by the public health department of the university to protect the university community from future occurrence of food poisoning.

Key words: Contamination, food, colony count, risk factors, handling

INTRODUCTION

Food borne illness caused by microbial contamination of foods is an important international public health problem and is known to be a major cause of diarrhoea diseases especially in developing countries (Mensah, 1997). In these developing countries a major source of ready-to-eat foods are prepared and or sold at public places such as schools, market places and along the streets, all together termed Street Foods (Sfs). The SFs offer food at relatively cheaper cost and at easily accessible places. Furthermore, it offers the traditional meals and preparations of a number of them are quite laborious and time consuming. Thus, with the increase in the number of hours spent at work places by parents (especially mothers) and schools; the importance of SFs in the provision of nutritional requirements is increasingly becoming very important among all socio-economic groups (Amoah, 1992; Chakravarty and Canet, 2002).

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However, a number of observational studies have shown that these foods are sometimes held at improper temperatures, excessively handled by food vendors and sold at very dirty surroundings (WHO, 2001, 2003; Agbodaze *et al*., 2005; Muinde and Kuria, 2005; Ghosh *et al*., 2007). In addition, the vendors practice poor personal hygiene and reports of food vendors being carriers and therefore could serve as a potential source of transmission of enteric fevers are many. Most of the vendors have had either no formal education or few years of schooling and therefore, lack knowledge on proper food handling and their role in the transmission of pathogens (Mensah *et al*., 1999). At the same time, most of the people who patronize these foods are more interested in its convenience than the question of its bacteriological quality and hygiene. The bacteriological quality of food indicates the amount of bacteria contaminants it has; a high level of contamination indicates low quality and more likely to transmit infection and the reverse is true (Anonymous, 1988). Thus concerns have been raised by the Food and Agricultural Organization (FAO) and others about these foods serving as a potential source of food poisoning outbreaks (Chakravarty and Canet, 2002).

In addition to SFs, the consumption of Western style Fast-Foods (FFs) like in developing economies (Bauer *et al*., 2009) is increasingly gaining popularity among Ghanaians especially within the middle class to high socioeconomic group. The FFs are foods that the preparations do not take much time compared to the typical location dishes that take long time to cook. These chains usually provide foods such as the corrupted Asian nasi goreng locally termed fried rice, fried chicken and salads. These foods are usually sold from enclosed buildings and to the best of our knowledge there are little or no studies that have analysed their microbial quality.

The University of Ghana currently, has a total of 29, 754 (2007/2008 academic year) students who are more than the workers. Like in other societal groups in Ghana, SFs and FFs are a major source of nourishment during the day. Most of the SFs are sold in designated open markets and around the main academic departments, whereas, the FFs are sold from sheltered restaurants in and around the campus. While, some students and workers depend on these foods for all their daily meals, most of them patronize them for at least one daily meal. In October 2007, an outbreak of acute gastroenteritis occurred on the university campus and affected thirty four students. A preliminary investigation revealed that all the affected patronized a food item sold from one of the open markets. Therefore, this study aimed to analyse the bacteriological quality of ready-to-eat foods sold in various parts of the university campus and to compare the quality of foods sold from the open markets to the restaurants.

MATERIALS AND METHODS

Study Sites

This study was conducted between November 2007 and February 2008. Five ready-to eat-food vending sites found in and around campus were sampled. These vending sites were chosen because they are very popular among both students and workers and members of both groups buy food from at least one of these places at one time or the other. They include three open market places (University market, Jubilee market and taxi rank) and enclosed restaurants that we designated as A and B. While the University market has a cemented floor, that of the taxi rank and the Jubilee market are not cemented and has dusty floors.

Sample Population and Collection of Samples

The main foods patronized by the students were identified and sampled and at least three vendors were selected for sampling from each open market. The food vendors in

Table 1: Description of local food items analysed

Food item	Description of food
Fried rice	Boiled white rice which is fried in oil and mixed with vegetables, eggs and spices
Salad	Vegetables such as cabbage, lettuce, cucumber and carrots are chopped into small portions, mixed together and salad cream added to it. It undergoes no form of cooking
Waakye	Beans and white rice boiled together
Tomato stew	Stew prepared with a lot of tomatoes
Black pepper	Prepared with little r no tomatoes, a lot of pepper, spices, dried fish or meat. This stew is cooked till all the water evaporates from it giving it a black colour. Excess oil is kept on it to preserve it as it can be kept for a long time without spoiling
Red pepper	A mixture of fresh tomatoes, red chilli pepper and onions are mashed in a local earthenware bowl (asanka) and served without undergoing any form of cooking
Macaroni	Pasta made from semolina (purified wheat flour) and shaped into slender tubes
Plain rice	White rice that is boiled. Some times a little oil is added to it during boiling
Beans stew	Boiled beans which are then mixed with already prepared tomato stew with fish

the markets were chosen by a simple random sampling method, without any order (Mensah *et al*., 2002) as various vendors sold the same foods. About 100 g portions of each food was carefully transferred into the sample containers which were covered tightly, labeled and transported on ice to prevent bacterial multiplication during sample transportation to the Bacteriology Department of the Noguchi Memorial Institute for Medical Research (NMIMR) (Amoah, 1992; Kumarasamy *et al*., 2009) where the analysis was done on the same day. The food items analysed are shown in Table 1.

Bacterial Counts

Ten grams portion of each food sample were macerated in 90 mL of phosphate buffered saline (Oxoid Dubelco A BR 14a, UNIPATH (Oxoid), Basingstoke, England) (Bagg *et al*., 1982) to make a 1:10 dilution. Further, tenfold serial dilution were made and examined by means of the pour plate method (Mensah *et al*., 2002). Briefly each plate was carefully labelled on top and 100 μL of diluted samples to be analysed piptted into the plate. Twenty five milliliter of cooled molten agar was poured over, swirled three times clockwise and three times anti-clockwise to mix thoroughly the sample in the medium. The medium was allowed to set on a flat-top bench, after which plates were incubated aerobically at 37°C. Plate Count Agar (Oxoid CM463) was used for the enumeration of Aerobic Colony Counts (ACC) and Mackonkey agar (Oxoid CM7) for Enterobacteriaceae Count (EC). Twenty one plates (7 each for the different group of bacteria) were used for each food sample analysed. Altogether 567 plates were used in the total counts analysis. After overnight incubation, counts were made using a colony counting device that allows viewing of individual colonies (Gallenkamp colony counter, UK). All plates were counted but those showing colony counts between 25 and 250 were selected and their colony forming unit per gram (cfu g^{-1}) calculated by multiplying the count by the dilution factor (Harrigan and McCance, 1968; Thatcher and Clark, 1968).

Species Identification

Forty milliliters of the 10^{-1} dilution was then poured into centrifuge tubes and centrifuged at 11000 rpm for 30 min in a refrigerated centrifuge (Hitachi 20PR-259, Tokyo, Japan). The supernatant was discarded and the pellets were directly streaked onto Salmonella Shigella (SS) agar (BBL 11597, BBL Microbiological Systems, MD, USA) and Mackonkey agar (Oxoid CM7) a differential medium for the detection of *Salmonella* sp., *Shigella* sp,. *E. coli* and other Enterobacteriacea. In addition several loopfuls of the pellet was inoculated into 10 mL Selenite broth; a liquid medium that enhances *Salmonella* sp. and *Shigella* sp. growth (Eiken 42001, Tokyo, Japan) for selective enrichment of *Salmonella* and *Shigella* and incubated a t 37°C for 18-24 h after which the tube was vortexed and streaked

on SS agar for the detection of isolated colonies of *Salmonella* sp. and *Shigella* sp. Suspected bacterial colonies from all the plates were sub cultured on SS/Mackonkey Agar to obtain pure cultures for morphological and biochemical identification. Triple Sugar Iron (TSI), Sulphur Indole Motility (SIM) and Analytical Profile Index (bio-Me'rieux SA, Marcy-l'E' toile, France) biochemical tests were then performed for suspected bacterial colonies to further identify them (Mensah *et al*., 2002; Donkor *et al*., 2008).

Data Analysis

For easy computations, all cfu g^{-1} values were converted to log10. Foods were then classified according to the values obtained after the conversion. Food were classified as acceptable if the ACC was less than or equal to 4 log10 cfu g^{-1} and if the counts of Enterobacteriacea were less than or equal to 3.0 log10 cfu g^{-1}. foods with values above these were classified as unsatisfactory and could be of high risk transmitting enteric pathogens (Anonymous, 2008; Thatcher and Clark, 1968). The microbial quality of the foods from the two sectors was compared using the student's t-test analysis which assesses whether the means of two groups are statistically different from each other. This analysis is appropriate whenever you are comparing small group; values less than 0.05 were considered significant.

RESULTS

Five study areas were used in the study, the Taxi Rank, the University market (Bush Canteen), the Jubilee market (Night Market), a restaurant outside campus that is popular among students that we designated as Site A and one inside campus that was designated as Site B. both site A and B are enclosed and therefore the cooking and vending areas are isolated from environmental contamination. The other sites Taxi Rank, University market and the Jubilee market were open and run the risk of their foods being contaminated by environmental bacteria. However, 14 of the 19 (73.7%) vendors in these markets served their foods from bowls enclosed in a rectangular mesh or a well covered glass box. Only two foods (10.5%) were kept on fire during sale whiles the other 17 (89.5%) were not kept on fire but left out and allowed to grow cold during sale.

A total of 27 foods were sampled from the five sites: 3, 5, 5, 7 and 7 were sampled from Site A, B and each of the open markets respectively. Four microbiological parameters, namely Aerobic Colony Count (ACC), total Enterobacteriacea, presence of *Escherichia coli* and other Enterobacteriacea and the presence of *Salmonella* sp. and *Shigella* sp. 70.4% (19/27) of the foods analysed had some level of bacteriological contamination. Forty eight percent (13/27) of the foods sold had total ACC values within acceptable limits, that is $<10^4$ cfu g^{-1} whiles, 52% (14/27) had ACC values above acceptable limits and therefore, unsatisfactory for consumption, 59.3% had EC values within the acceptable limits whiles 40.7% had EC values above the limit. On comparing the means of the ACC values, it was found that there was no difference between the quality of foods sold from the two sectors (t-test< t-value: 0.397<2.06).

Ten different bacterial species were isolated from the foods sampled. These were *E. coli*, *Klebsiella pneumoniae*, *Streptococcus* sp., *Enterobacter cloacae, Bacillus* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus* sp., *Streptococcus agalactiae* and *Enterococcus faecalis.* No *Salmonella* or *Shigella species* were isolated. Table 2 gives a summary of the bacteriological quality of the different foods analysed. As shown in Table 3 we did not find a difference between the quality of foods sold in the open markets and that of the restaurants.

Table 2: Bacteriological quality of food samples analysed

Food item	NT	NC	Mean (cfu g^{-1})	*E. coli*	*P. aeruginosa*	*S. aureus*	*K. pneumoniae*	*Streptococcus* sp.
Fried rice	2	2	1.78×10^{4}	nd	nd	nd	+	nd
Salad	7	7	3.48×10^{8}	+	+	nd	+	+
Waakye	3	1	1.39×10^{5}	+	nd	+	nd	+
Tomato stew	2	1	1.60×10^{3}	nd	nd	nd	+	nd
Black pepper	2	2	4.60×10^{3}	nd	nd	nd	+	nd
Food item	NT	NC	Mean (cfu g^{-1})	*Bacillus* sp.	*Proteus* sp.	*E. cloacae*	*Enterococcus* sp.	
Fried rice	2	2	1.78×104	nd	nd	+	nd	
Salad	7	7	3.48×108	nd	+	+	+	
Waakye	3	1	1.39×105	+	nd	+	nd	
Tomato stew	2	1	1.60×103	nd	nd	+	+	
Black pepper	2	2	4.60×103	+	nd	nd	+	

Table 3: Comparing food quality between the open markets and the restaurants

	Open markets			Restaurants		
Food item	No. of tested	No. of contaminated	Mean (cfu g^{-1})	No. of tested	No. of contaminated	Mean (cfu g^{-1})
Fried rice	1	1	3.1×10^{4}	1	1	4.6×10^{3}
Salad	5	5	4.86×10^{8}	2	2	2.6×10^{6}
Waakye	3	1	1.39×10^{5}	0	0	0
Tomato stew	1	1	1.60×10^{3}	1	0	0
Black pepper	1	1	9.00×10^{3}	1	1	2.0×10^{2}
Red pepper	3	2	5.50×10^{9}	0	0	0
Macaroni	3	3	1.01×10^{9}	1	1	$>10^{10}$
Plain rice	2	0	0	1	0	0
Beans stew	0	0	0	1	0	0

DISCUSSION

Pathogenic bacteria are the most common known causes of food contamination and food borne illnesses. This study therefore, aimed to analyse the bacteriological profile of ready-to-eat foods sold on various parts of the University of Ghana campus. A total of 27 randomly collected food samples were included in the study. The 70.4% (19/27) of the foods sampled confirmed the presence of bacterial pathogens and 10 different bacterial species were isolated from the different samples analysed. In this study we did not isolate any *Salmonella* sp. and *Shigella* sp. Nevertheless, the detection of *E. coli* and other Enterobacteria are indicative of possible faecal contamination and hence, the risk of the foods transmitting such high pathogenic bacteria upon consumption (Anonymous, 2008). In addition, the presence of *S. aureus*, an enterotoxin producer which can cause serious gastroenteritis (Balaban and Rasooly, 2000) and *Ps. aeruginosa*, an opportunistic pathogen, is known to cause food spoilage and can lead to economic loss (Liao, 2006) must be of outmost concern.

The main dishes such as Waakye and plan rice had either no counts or contamination within the acceptable limits. This could be that these foods are generally boiled for long periods and they were sampled early in the morning when they were hot and had not been excessively handled. These foods are handled excessively during sale and therefore sampling the foods when they have been on sale for hours would also produce different results. Amoah (1992) sampled similar foods in Kumasi the second largest city in Ghana after Accra and found that the level of contamination of Waakye samples was proportional to the length of time the food has been displayed and recommended that future studies be done to find out whether the situation in Accra is different from Kumasi.

The black peppers (shito) had counts within the limit and this could be due to the method of preparation and storage. This pepper is prepared by cooking on the fire for a long

time to get almost all the water out till it turned black and stored in tightly closed containers with some quantity of oil on it. The oil prevents the penetration of oxygen and therefore, provided conditions that are unsuitable for the growth of Enterobacteria and other aerobic bacterium as they require oxygen for their growth. In addition such stews had most of the water evaporated during excessive heating and thus have very low water quantity which provides less favorable conditions for bacteria growth.

The macaroni and salads however had very high levels of bacterium. This is also consistent with work done on these foods (Amoah, 1992; Mensah *et al*., 2002). Macaroni is prepared by boiling in hot water for a few minutes and draining the water from it. Though the water is drained from the food, it still has a moist appearance and this provides a good environment for bacterium growth. It is also sometimes mixed with tomato stew after cooking and this makes it very rich and could also account for the level of contamination. The salads however are prepared by chopping and mixing raw vegetables. This food undergoes no form of cooking and therefore, the bacteria that contaminate it in the field and during processing are not killed and multiply in the food. Also in Ghana during cultivation, vegetables are irrigated with polluted water, especially those grown in the cities where there are not many water bodies and therefore a high level of contamination is not unexpected (Mensah *et al*., 2002; Donkor *et al*., 2008; Ghosh *et al*., 2007) if the vegetables are not thoroughly washed. However, this can be improved through proper education as has been confirmed by a study in South Africa (Von Holy and Makhoane, 2006), who found that the quality of street foods is not as bad as previously conceived.

The red peppers sampled however had contamination levels above the acceptable limit. This pepper is prepared by mashing tomatoes, onions and pepper in an earthenware bowl and is eaten without heating. The earthenware bowl is used in our Ghanaian homes for the mashing of all foods. This bowl is usually not thoroughly washed as there is a belief that this bowl should not be washed using soap. This bowl could therefore have an accumulated bacterium load already in it since, different foods are mashed init. In addition, most vendors of street foods go for very cheap quality vegetables (usually broken), which are already bought from markets with very unhygienic surroundings. These vegetables are also handled excessively during sale and this handling could also introduce some level of contamination into the foods.

These findings (52 and 59.3% of the foods sampled having total aerobic colony counts and Enterobacteriacea counts above the acceptable limit, respectively), indicates the need for stricter implementation of food sanitation practices to reduce the possible risk of transmission of infection on consumption of these foods in future. In addition there is the need for educating the vendors and hired helps on safe food handling practices and proper hygienic practices, particularly proper hand washing.

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REFERENCES

Agbodaze, D., P.N.A. Nmai, F.C. Robertson, D. Yeboah-Manu, K. Owusu-Darko and K.K. Addo, 2005. Microbiological quality of khebab consumed in the Accra metropolis. Ghana. Med. J., 39: 19-29.

Amoah, D.K., 1992. Some studies on street foods in Kumasi. Dissertation Submitted to the Department of Biochemistry, University of Science and Technology, Ghana.

Anonymous, 1988. Bacteriological quality. http://dsp-psd.pwgsc.gc.ca/Collection/H48-10-1-3-1991E.pdf.

Anonymous, 2008. Guidelines for determining the microbiological quality of food. Prepared January 2008. http://symbioalliance.com.au/files/guidelines-for-determining-the-microbiological-quality-of-food.pdf.

Bagg, J., I.R. Poxtond, M. Weir and P.W. Ross, 1982. Binding of type-I11 group-B Streptococci to buccal epithelial cells. J. Med. Mlcroblol., 15: 363-372.

Balaban, N. and A. Rasooly, 2000. Staphylococcal enterotoxins. Int. J. Food Microbiol., 61: 1-10.

Bauer, K.W., N.I. Larson, M.C. Nelson, M. Story and D. Neumark-Sztainer, 2009. Fast food intake among adolescents: Secular and longitudinal trends from 1999 to 2004. Prev. Med., 48: 284-287.

Chakravarty, I. and C. Canet, 2002. Street foods in Calcutta. http://www.fao.org/docrep/W3699T/W3699T06.HTM.

Donkor, E.S., R. Lanyo, M.L. Akyeh, B.B. Kayang and J. Quaye, 2008. Monitoring enterohaemorrhagic *Escherichia coli* O157: H7 in the vegetable food chain in Ghana. Res. J. Microbiol., 3: 423-428.

Ghosh, M., S. Wahi, M. Kumar and A. Ganguli, 2007. Prevalence of enterotoxigenic *Staphylococcus aureus* and *Shigella* sp. in some raw street vended Indian foods. Int. J. Environ. Health Res., 17: 151-156.

Harrigan, F.W. and M.E. McCance, 1968. Laboratory Methods in Food Microbiology. Academy Press, London.

Kumarasamy, P., S. Vignesh, R. Arthur James, K. Muthukumar and A. Rajendran, 2009. Enumeration and identification of pathogenic pollution indicators in Cauvery River, South India. Res. J. Microbiol., 4: 540-549.

Liao, C.H., 2006. Food Spoilage Microorganisms. In: Pseudomonas and Related Genera, Blackburn, C.W. (Ed.). Woodhead Publishing Ltd., Cambridge, UK.

Mensah, P., 1997. Persistent diarrhoea in Ghana. Report Submitted to Japan International Cooperation Agency.

Mensah, P., D. Yeboah-Manu, K. Owusu-Darko, A. Ablordey, F.K. Nkrumah and H. Kamiya, 1999. The role of street food vendors in the transmission of enteric pathogens. Ghana Med. J., 33: 19-29.

Mensah, P., D. Yeboah-Manu, K. Owusu-Darko and A. Ablordey, 2002. Street foods in Accra, Ghana: How safe are they?. Bull. WHO, 80: 546-554.

Muinde, O.K. and E. Kuria, 2005. Hygienic and sanitary practices of vendors of street foods in Nairobi, Kenya. Afr. J. Food Agric Nutr. Dev., 5: 1-15.

Thatcher, P.S. and D.S. Clark, 1968. Microorganisms in Foods: Their Significance and Methods of Enumeration. Vol. 1, University of Toronto Press, Toronto, ISBN: 0-8020-2293-6.

Von Holy, A. and F.M. Makhoane, 2006. Improving street food vending in South Africa: Achievements and lessons learned. Int. J. Food Microbiol., 111: 89-92.

WHO, 2001. Background paper: Developing a food safety strategy. WHO Strategic Planning Meeting. Geneva. https://apps.who.int/fsf/Documents/BACKGROUND%20PAPER.pdf.

WHO, 2003. Module A decentralization policies and practices: Case study Ghana. Participants Manual, Geneva. http://info.worldbank.org/etools/docs/library/205756/sloga/docs/sloga/MODA-EN-CaseStudyGhana.pdf.