Annals. Food Science and Technology
2012

ASSESSING THE MICROBIOLOGICAL QUALITY OF FOOD SOLD ON AND AROUND KOFORIDUA POLYTECHNIC CAMPUS IN GHANA

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Abstract
In developing countries, street food plays a major role in the nutritional requirements of many people especially those whose schedule take them away from home during the day and sometimes in the night. Street food though cheap and convenient may be a vehicle for food-borne diseases and food poisoning if it is not handled properly. In recent times there have been reported cases of food-borne diseases such as typhoid fever, diarrhea and other intestinal related diseases which may be attributed to consumption of contaminated food and water. This provided the basis for this research. The aim of the research was to assess the influence of hygienic practices of food vendors on microbiological quality of food sold on and around Koforidua Polytechnic campus, Ghana. The study was conducted through questionnaire administration, interviews, personal observation and microbial count analysis. The microbial count for Escherichia coli, Salmonella and Staphylococcus aureus were conducted on selected food samples, and the results from the total viable count (TVC) test showed that E. coli ($> 1.0 \times 10^3 \pm 1.1 \times 10^1$*) and S. aureus (*$>7.0 \times 10^3 \pm 1.0 \times 10^1$*) detected in fufu samples were beyond the acceptable limits, while the S. aureus (*$< 1.0 \times 10^2 \pm 2.0 \times 10^0$*) found in waakye samples was below satisfactory but above unsatisfactory levels. However, Salmonella was not detected in meat, soup and stew samples. The level of hygiene consciousness of the food vendors was found to be low therefore vendors should be educated on hygiene practices.*

Keywords: Food vendors, hygienic practices, contamination, diseases, microbial count

Submitted: 29.06.2012 Reviewed: 13.07.2012 Accepted: 27.07.2012

1. INTRODUCTION

There are many reasons why people eat away from home. These include absence from home whiles travelling, studying, whiles at work or need for a change both in terms of food type and the location. As a result many people purchase food from the streets. The quality of street food just like any other food is determined by the nutrient content and its safety among others. Food and Agriculture Organization (FAO, 1989). defines street food as "ready-to-eat" food and beverage prepared and/or sold by vendors and handlers especially along the streets and other similar places for immediate consumption, or consumption at a later stage without further processing or preparation. Even though street food is relatively cheap and easily accessible (Latham, 1997) it has its associated health problems (Omemu and Aderoju, 2008). Since street food is ready-to-eat and does not usually go through further processing it can be a good vehicle for food-borne microbial organism transmission into the body, if it is not handled properly. Bacteria such as *Salmonella species*, *Staphylococci aureus* and *Escherichia coli,* which can be conveyed by food, cause food poisoning and other food-borne diseases such as tuberculosis, typhoid fever and cholera (Foskett et al., 2003), dysentery, diarrhea and food poisoning (Macleod and Douglas, 1999) and pneumonia, meningitis, whooping cough, hepatitis and sore throat (Gates, 1987). The cost of food-borne illnesses may be expensive. In the USA it is estimated that the total cost of food-borne illness is almost $152 billion per annum (Scharff, 2010).

Many workers have reported extensively on the safety of ready-to-eat foods. Oranusi and Braide (2012) investigated the microbial safety of ready-to-eat foods sold along Onitsha-Owerri highway and found out that even though some of the foods studied were contaminated beyond acceptable microbiological limits, most were of acceptable microbiological standard. In a related study undertaken in Benin City in Nigeria, ready-to-

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to-eat rice from standard fast food centers was found to have higher microbial load than that from local fast food centers (Wogu, 2011). A survey conducted among street food vendors in Gauteng, South Africa revealed that most of them observed a high standard of hygiene during food preparation and serving, with the results of microbiological counts corroborating it (Martins and Com, 2006).

Screening of 204 food vendors was carried out in Accra, Ghana to assess the prevalence of intestinal parasitic infections among them (Ayeh-Kumi et al 2009). Another study was also undertaken on the streets of Accra to ascertain the microbial safety of food and the underlining causes of food contamination (Mensah et al., 2002). It was revealed in a study involving 50 street vendors that only 40% possessed health certificates which authorized them to sell food (Ackah et al., 2011).

The microbial quality of ready-to-eat foods on the University of Ghana campus was studied (Yeboah-Manu et al., 2010). Most ready-to-eat foods in Kumasi, Ghana were reported to be contaminated with enteric bacteria, and had bacterial counts higher than the acceptable levels (Feglo and Sakyi, 2012). A study on microbiological safety of tiger nuts (*Cyperus esculentus* L.) in the Cape Coast Metropolis of Ghana concluded that non-sterilized tiger nuts were contaminated with high bacteria load but that surface sterilization held the potential of reducing it (Nyarko et al., 2011).

The human resources of every organization are important in the realization of its goals. Illnesses caused to staff and students of Koforidua Polytechnic as a result of consumption of unhygienic food may lead to loss of working days and productivity, expenses on medicines, distress and possible death (Sprenger, 1999). Therefore measures should be put in place to ensure that they purchase food of acceptable microbiological quality. This can only be done when the sources from which they purchase food are assessed to know the level of food safety.

Against this background, food vendors in and around Koforidua Polytechnic campus, Ghana was assessed to determine the level of hygienic practices they observe and how that influences the microbiological quality of food sold. Therefore the objectives of the study were to assess the food handling practices exhibited by vendors and to determine the microbial load of food sold.

2. MATERIAL AND METHODS

The main methods used in the study included questionnaire/interview administration, observation and the microbial load count analysis of the major food sold on and around Koforidua Polytechnic campus, Ghana.

Questionnaire

Structured questionnaires were administered randomly to both workers (staff) and students of the institution to identify the various places where food is bought and to ascertain the food handling practices of vendors. The information gathered from the questionnaire provided the basis for identifying the major places where food is bought and the food frequently consumed. Samples of the popular food bought by staff and students were analyzed for their microbial count (Martins, 2006).

The study population was stratified into two, namely staff and students. A total of 620 questionnaires were administered to staff and students randomly. This was made up of 120 staff members (out of about 500) and 500 students (out of 2,451 students). The major places where staff and students purchase food were identified, and coded as A, B, C, D, E, F and G. Three vendors each from the various identified food sale points were interviewed and personal observation conducted in addition. The interview and the observation covered areas such as training in hygiene, hygiene knowledge, hygiene of premises, personal hygiene, food hygiene, and waste handling.

MICROBIAL COUNT TEST

Sample collection

Samples of the most popular foods bought by staff and students were bought from the

identified places, kept in a cooler box containing ice, and sent to the Ghana Standards Board for microbial count test. The samples taken were *fufu, waakye, soup, sauce and goat meat.*

Description of tested food

Fufu is a mashed food pounded by using cassava and plantain/cocoyam/yam. During pounding the hand is used to turn it, and can thus be contaminated with microbes, especially *Staphylococcus aureus* and *Escherichia coli.* It was thus analyzed for these two microorganisms. *Waakye* is a mixture of rice and beans cooked together. Beans is a protein food and thus a high risk food, therefore susceptible to microbes, so it was analyzed for *Staphylococcus aureus*. Goat meat, soup and sauce were analyzed for *Salmonella spp*. Soup and sauces are made by using vegetables and meat or fish. These are all good sources of protein and hence highly susceptible to microbial contamination.

Method for determination of microorganisms

Detection of *Staphylococcus aureus*

Ten grammes of the samples of *waakye* and *fufu* were aseptically weighed into 90 ml of sterile Maximum Recovery Diluent (MRD). This provided the 10^{-1}dilution. With a sterile pipette, 1 ml of the 10^{-1} dilution was pipette into 9 ml of sterile MRD to obtain 10^{-2} dilution, and 0.1 ml of each dilution was pipetted onto a Rabbit Plasma Fibrinogen (RPF) Agar plate and spread uniformly with a glass spreader. The plates were inverted and incubated at 37°C for 24 h. The plates were examined for typical colonies of *S. aureus* (black, grey colonies with halos) and other species.

Calculation

The number (N) of *S. aureus* colonies was calculated using the formula:

$$N = \frac{\sum C}{V\,(N1 + 0.1N2)\,d}$$

Where ∑C = sum of characteristic Staphylococcus colonies

V = volume of inoculum on each dish

N_1 = number of plate at first dilution

N_2 = number of plate at second dilution

d = dilution rate corresponding to the first dilution

Detection of *Escherichia coli*

Ten gramme of *fufu* sample was weighed aseptically into 90 ml of MRD to obtain the initial dilution of 10^{-1}. Two further dilutions of 10^{-2} and 10^{-3} were also prepared. One millilitre of the 10^{-1}dilution was transferred into 9 ml of three tubes containing lauryl tryptose broth with Durham tubes. This procedure was repeated for the 10^{-2} and 10^{-3} dilutions. The inoculated tubes were incubated at 37°C for 24 h. Positive tubes (those tubes which show gas formation and cloudiness) were sub-cultured aseptically into *Escherichia coli* Broth (ECB) tubes containing Durham tubes and incubated at 44°C for 24 ± 2 h. Positive tubes were then sub-cultured into tubes of tryptone water (5 ml) and incubated at 44°C for 24 ± 2 h. The cultures were treated with 3 drops of Kovac's reagent. The change in colour to red (red ring at the liquid meniscus) indicates the presence of *E. coli*.

Detection of *Salmonella spp.*

Ten gramme of the soup, sauce and goat meat samples was weighed aseptically into 90 ml of peptone water and incubated at 37°C ± 1°C for 18 ± 2 h. One ml of this culture was pipetted into 10 ml of Rappaport-Vasilliadis (RVS) broth and 10 ml tetrathionate (TT) broth. These were incubated at 41.5°C ± 1°C for 24 ± 3 h and 37°C ± 1°C for 24 ± 3 h respectively. Each of the cultures was streaked onto two agar plates – bismuth sulphite agar (BSA) plate and xylose lysine deoxycholate (XLD) agar plate. The agar plates were incubated at 37°C ± 1°C for 24± 3 h. The plates were examined for typical colonies of *Salmonella spp.* The XLD plate was examined for gray, black, green colonies with or without metallic sheen while BSA plate was examined for pink colonies with or without black centers.

Data analysis

The questionnaires were sorted and tallied by the research team and coding was done to ensure the confidentiality of the eating places. The values were converted into percentages and presented as tables. Data from the microbial count test was also presented in a table.

3. RESULTS AND DISCUSSION

Hygiene and hygienic practices of food vendors

The study aimed at finding out how food handling practices influence the microbiological quality of food. As a result two main methods were used to achieve this. The first part utilized questionnaire, interview and observations to collect data about how food is handled by vendors, and the second part dealt with how the food handling practices affect microbiological quality of food.

The interviews and observation conducted on 21 food vendors, 3 from each of the 7 identified food sale points, indicated that only 23.8% of them had training in food hygiene and safety, and less than 40% had knowledge on microorganisms and food contamination (Table 1). In a related study (Isara et al., 2006) also found that less than half of the food vendors studied in Benin City, Nigeria had undergone training in food hygiene and safety. The present results may be attributed to the notion held by most people that a person does not need any formal training before preparation and sale of food. The results (Table 1) also show that none (0%) of the 21 food vendors had undergone any form of medical examination to be certified to handle food. This is far lower than 29.7% reported in a previous study (Isara et al., 2006). In a recent study it was also shown that only 40% of food vendors had taken medical examination (Ackah et al., 2011). Another study also found out that only 31% of food vendors had health certificates (Omemu and Aderoju, 2008). The present result may be due to ignorance on the part of the food vendors and non-enforcement of laws governing establishment and operation of food outlets. The possibility that some of the vendors may harbour microbes which can transmit illnesses such as, tuberculosis, typhoid fever and cholera (Foskett et al., 2003), diarrhea and dysentery (Macleod and Douglas, 1999) cannot be ruled out. This is serious because such illnesses may be transferred to food consumers. The level of hygienic knowledge influenced the handling practices of the vendors. The study revealed that less than 40% demonstrated good knowledge about microorganisms, how they cause contamination and their symptoms in the body. Vendors who cover their hair during food preparation and service were 28.6%, and this is far lower than 34.5% found in a previous study in Gauteng, South Africa (Martins and Com, 2006). People who prepare food for the public should cover their hair as the hair carries high bacteria count and may cause contamination when it falls into the food (Gates, 1987). All the vendors (100%) wash their hands after visiting the toilets. This is comparable to 97.0% reported in a similar study in South Africa (Martins and Com, 2006). High percentage of food vendors (61.9%) washes their hands with cold water and soap. Even though this is good as it can help to lower microbial load on the hands of food vendors, hot water and soap could be the best option. A good percentage of food vendors (47.6%) dishes out food with their bare hands. During food service clean tong, spatula, etc. should be used to minimize the use of the hand (Brownsell, 1992). *Staphylococcus aureus* are present on human hands and other parts of the skin, sores, spots, etc., nose and throat (Foskett et al., 2003). Therefore using the bare hand to dish out food increases the susceptibility of the food to contamination by *S. aureus.* Out of the total number of vendors 85.7% of them do not expose their food to flies and dust (Table 1). This may be due to the fact a good number of them (71.4%) knows that flies can transfer germs.

Table 1: Observation and interview results on food vendors

Parameter	Frequency		Percent (%)	
	YES	NO	YES	NO
GENERAL (N=21)				
Training in food hygiene and safety	5	16	23.8	76.2
Certificate of training	5	16	23.8	76.2
Medical examination before commencement of work	0	21	0	100
Repeat medical examination	0	21	0	100
Knowledge that those suffering from diarrhea, coughing, sneezing, septic boils etc should not handle food	7	14	33.3	66.7
Knowledge that microorganisms can contaminate food	8	13	38.1	61.9
Knowledge of symptoms of eating food contaminated by microorganisms	6	15	28.6	71.4
Knowledge that flies transfer germs to food	15	6	71.4	28.6
HYGIENE OF PREMISES (N=7)				
Clean premises	6	1	85.7	14.3
Presence of stagnant water	0	7	0	100
Presence of flies	2	5	28.6	71.4
PERSONAL HYGIENE (N=21)				
Cover hair in net/cap	6	15	28.6	71.4
Clean/short nails	15	6	71.4	28.6
Wear apron	6	15	28.6	71.4
Wash hands after visiting the toilet	21	0	100	0
Wash hands before handling food	2	19	9.5	90.5
Wash hands after handling raw food	15	6	71.4	28.6
Wash hands in between food handling operations	4	17	19.0	81
Wash hands after eating/drinking	2	19	9.5	90.5
Wash hands after handling money	3	18	14.3	85.7
Wash hands after handling waste food	21	0	100	0
Wash hands with cold water only	8	-	38.1	-
Wash hands with hot water only	0	21	0	100
Wash hands with cold water and soap	13	-	61.9	-
Wash hands with hot water and soap	0	21	0	100
FOOD HYGIENE (N=21)				
Exposure of food to flies/dust	3	18	14.3	85.7
Dishing of food with bare hand	10	-	47.6	-
Serve food with ladle/spatula/tongs	11	-	52.4	-
Eat during food service	2	19	9.5	90.5
Taste food with fingers	7	-	33.3	-
Taste food with clean spoon	14	-	66.7	-
Blows air into polythene bag used for serving food	3	18	14.3	85.7
Lick hands to separate paper sheets for serving food	0	21	0	100
WASTE DISPOSAL (N = 7)				
Possession of waste bin	7	0	100	0
Waste bin with no lid	2	-	28.6	-
Waste bin with loose lid	1	-	14.3	-
Waste bin with tight-fitting lid	4	-	57.1	-
Waste bin with lid and foot-operated	-	-	-	-

Table 2: Food purchases response by consumers

Type of food	Fufu and soup/meat	Waakye and stew/meat	Kenkey	Garri and beans	Ampesi	Fried rice	Total
Consumers	250	150	53	100	17	50	620
Percentage	40.3	24.2	8.5	16.1	2.7	8.1	100

Microbial count

In the survey involving 620 people, consisting of 120 staff and 500 students of Koforidua Polytechnic, it was observed that most of them usually purchase *fufu* and soup/meat, and *waakye* and stew/sauce/meat (Table 2). Accordingly *fufu, waakye*, soup, sauce, and meat were analyzed for their microbial counts.

The results on bacterial count are shown in Table 3. *Escherichia coli* detected in *fufu* from the places A and C was >1.0 x 10^3 cfu/g. This is comparable to 1.1 x 10^3–4.1 x 10^3 cfu/g reported for plantain chips, but far lower than 4.1x10^3-3.8x10^3 cfu/g for wall nut obtained from 6 different sampling points along Onitsha-Owerri highway (Oranusi and Braide, 2012). In a study of 87 meat/chicken samples from Gauteng in South Africa, 5.7% were shown to contain *E. coli* (Martins and Com, 2006). Even though the samples collected at the beginning of sales in three different sites at Hulu Langat District in Malaysia contained no *E. coli,* those collected in the night of the same day did (Alyaaqoubi et al., 2006). Chukwuemeka et al. (2010) reported 6.50$\log_{10}$ cfu/g of *E. coli* in cassava *foofoo*, and this was far greater than 3$\log_{10}$ cfu/g obtained for *fufu* in the present study. The results are also in the range 1.0-8.77 $\log_{10}$ cfu/g reported for fresh vegetables (Halablab et al., 2011). However, in accordance with the PHLC guidelines (Table 4), the levels of *E. coli* detected in *fufu* is unacceptable. The detection of *E. coli* in *fufu* in the present study may be due to human or animal faecal contamination and likelihood of pathogenic contamination, and this is an indication of poor hygiene (Sprenger, 1999). This is very serious as according to (Mehas and Rodgers, 1997) a strain of pathogenic *E. coli*, 0157:H7 secretes a powerful toxin that damages the cells lining the intestinal wall, causing cramps and diarrhea. *Fufu* processing relies heavily on handling, and this might have contributed to the detection of *E. coli* in it. There are several pathogenic types of *E. coli* that have been found to cause diarrhea which is a major public health concern
all-over the world, with over 2 million deaths recorded annually (WHO, 2002).

The *Staphylococcus aureus* recorded for *fufu* from the locations A and C were 7.0 x10^3 and 5.0 x 10^3 cfu/g respectively. This is extremely high compared with < 10 cfu/g detected in 3 samples of meat/chicken and 13 samples of maize meal porridge (Martins and Com, 2006). Alyaaqoubi et al. (2009) studied fourty-eight ready-to-eat foods in three different sites at Hulu Langat District in Malaysia and detected no *S. aureus* in them. The present results of 3.85$\log_{10}$ and 3.70$\log_{10}$ cfu/g of *S. aureus* detected in *fufu* from locations A and C are also high compared with 2.9± 0.55 and 3.5 ±1.01 $\log_{10}$ cfu/g reported for rice and beans respectively (Sina et al., 2011) though unacceptably comparable to 3.7$\log_{10}$-4$\log_{10}$ cfu/g found for salad and macaroni dishes in Accra, Ghana (Mensah, et al., 2002). Moreover, the present figures were within the range 10^2 - <10^4 described by PHLC guidelines (Table 4) as unsatisfactory for *S. aureus.* (Foskett et al., 2003) have observed that *S. aureus* is usually present on human hands, sores, nose, throat and other parts of the skin. They further contend that foods which are affected by *S. aureus* are those which have been handled with hands infected from the nose, throat, etc. It is logical to state that the samples of *fufu* from the above named two places were contaminated with *S. aureus* probably because the hands which handled them were contaminated. This is very disturbing against the background that *fufu* is one of the foods patronized by most students and staff of the study area, so for it to be handled in such manner lives much to be desired. *Staphylococcus aureus* was also detected in *waakye*, though at lower levels (<1.0x10^2 cfu/g) than that of *fufu*. This was far greater than < 10 cfu/g detected in samples of meat/chicken and maize meal porridge (Martins and Com, 2006). However, the present result of 2$\log_{10}$ cfu/g for *waakye*, a composite food of rice and beans is lower than 2.9± 0.55 and 3.5 ±1.01 $\log_{10}$ cfu/g reported for cooked rice and beans respectively (Sina et al., 2011) and 2.3-4.48$\log_{10}$ cfu/g found for boiled rice (Sudershan et al., 2012). The results from the observation indicated that *waakye* is dished

out using the bare hand. It is therefore not surprising that *S. aureus* were detected in the *waakye*. Thus there was contamination on the hand, perhaps from the nose, throat, cuts, etc. The presence of *S. aureus* in food is an indication that such food is potentially hazardous, and shows that there is a breakdown in personal hygiene or the handling of food (Sprenger, 1999).

Salmonella was not detected in soup from locations A and C, stew from location B, and goat meat from locations A and C. This is in line with the results reported for meat/chicken and maize meal porridge where no *Salmonella* was detected (Martins and Com, 2006). In another study involving fourty-eight ready-to-eat foods in three different sites at Hulu Langat District in Malaysia, *Salmonella* was not detected (Alyaaqoubi et al., 2009). A previous report on ready-to-eat samples from 20 University restaurants in Valencia, Spain also found no *Salmonella* (Soriano et al., 2001). A recent study also found no *Salmonella* in lime and lemon juices, but it was detected in pineapple and orange juices (Ukwo et al., 2008). However, 2.6 $\log_{10}$ cfu/g *Salmonella* was detected in chicken noodles, though not detected in chicken fried rice (Sudershan et al., 2012). Even though ready-to-eat foods containing *Salmonella* or other pathogens may not always cause illness, there is good microbiological and epidemiological evidence that small numbers of pathogens in foods have caused illness (Commission Decision 97/878/EC of 23 December 1997).
Therefore in the view of (Gilbert et al., 2000) it is not justifiable for processed ready-to-eat foods to be contaminated with these organisms, and that if present, even in small amounts, they make the food unacceptable. Therefore non detection of *Salmonella* in the soup, stew and meat makes these foods acceptable. According to (Foskett et al., 2003), when a person visits the toilet and does not wash the hands properly, the hands can contaminate food with *Salmonella* when used to handle food. From the observations made it was realized that vendors do not handle soup, stew and meat after processing. Therefore after the above foods are prepared, the hands do not contaminate them. This may account for the reason why *Salmonella* was not detected in the above named foods.

4. CONCLUSION

The influence of hygienic practices on microbiological quality of street food was studied. The results from the study indicate that the level of hygienic knowledge of food affects the food handling practices of food vendors, and hence the microbiological quality of the food they sell. Regular training on hygienic food handling practices could equip the food vendors produce and sell safe food.

5. ACKNOWLEDGEMENT

We are grateful to the Applied Research Fund of Koforidua Polytechnic for the financial support provided for this project. We are also very grateful to Professor Benjamin Simpson of McGill University Montreal, Canada for editing and offering constructive suggestions to the document.

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