Street foods in Accra, Ghana: how safe are they?

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Objective To investigate the microbial quality of foods sold on streets of Accra and factors predisposing to their contamination.
Methods Structured questionnaires were used to collect data from 117 street vendors on their vital statistics, personal hygiene, food hygiene and knowledge of foodborne illness. Standard methods were used for the enumeration, isolation, and identification of bacteria.
Findings Most vendors were educated and exhibited good hygiene behaviour. Diarrhoea was defined as the passage of $\geqslant 3$ stools per day) by 110 vendors (94.0%), but none associated diarrhoea with bloody stools; only 21 (17.9%) associated diarrhoea with germs. The surroundings of the vending sites were clean, but four sites (3.4%) were classified as very dirty. The cooking of food well in advance of consumption, exposure of food to flies, and working with food at ground level and by hand were likely risk factors for contamination. Examinations were made of 511 menu items, classified as breakfast/snack foods, main dishes, soups and sauces, and cold dishes. Mesophilic bacteria were detected in 356 foods (69.7%): 28 contained *Bacillus cereus* (5.5%), 163 contained *Staphylococcus aureus* (31.9%) and 172 contained Enterobacteriaceae (33.7%). The microbial quality of most of the foods was within the acceptable limits but samples of salads, macaroni, fufu, omo tuo and red pepper had unacceptable levels of contamination. *Shigella sonnei* and enteroaggregative *Escherichia coli* were isolated from macaroni, rice, and tomato stew, and *Salmonella arizonae* from light soup.
Conclusion Street foods can be sources of enteropathogens. Vendors should therefore receive education in food hygiene. Special attention should be given to the causes of diarrhoea, the transmission of diarrhoeal pathogens, the handling of equipment and cooked food, hand-washing practices and environmental hygiene.

Keywords Food services; Food contamination; Food handling; Food microbiology; Diarrhea/etiology; Risk factors; Ghana (*source: MeSH, NLM*).

Mots clés Restauration; Contamination alimentaire; Traitement aliments; Microbiologie alimentaire; Diarrhée/étiologie; Facteur risque; Ghana (*source: MeSH, INSERM*).

Palabras clave Servicios de alimentación; Contaminación de alimentos; Manipulación de alimentos; Microbiología de alimentos; Diarrea/etiología; Factores de riesgo; Ghana (*fuente: DeCS, BIREME*).

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Voir page 552 le résumé en français. En la página 553 figura un resumen en español.

Introduction

Foodborne illness is a major international health problem and an important cause of reduced economic growth (*1*). There is concern about, for example, chemical contamination, *Escherichia coli* O157:H7 infections, the use of antibiotics in animal rearing and the transfer of antibiotic resistance to human pathogens (*2*).

The problems of food safety in the industrialized world differ considerably from those faced by developing countries. Whereas traditional methods are used for marketing fresh produce in the latter countries, food processing and packaging are the norm in industrialized countries. In developing countries a large proportion of ready-to-eat food is sold on the streets. Table 1 shows some of the foods sold on the streets in Ghana.

The term "street food" refers to a wide variety of ready-to-eat foods and beverages sold, and sometimes prepared, in public places. As with fast food, the final preparation occurs when meals are ordered by customers. Street food may be consumed where it is purchased or can be taken away and eaten elsewhere.

The consumption of street food is common in many countries where unemployment is high, salaries are low, work opportunities and social programmes are limited, and where urbanization is taking place. Street food vendors benefit from a positive cash flow, often evade taxation, and can determine their own working hours. In selling snacks, complete meals, and refreshments at relatively low prices, they provide an essential service to workers, shoppers, travellers, and people on low incomes. People who depend on such food are often more interested in its convenience than in questions of its safety, quality and hygiene.

The hygienic aspects of vending operations are a major source of concern for food control officers. For example, stands are often crude structures, and running water may not be readily available. Also toilets and adequate washing facilities are rarely available. The washing of hands, utensils, and dishes is often done in buckets or bowls. Disinfection is not usually carried out, and insects and rodents may be attracted to sites where there is no organized sewage disposal. Finally food is not adequately protected from flies and refrigeration is usually unavailable.

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Table 1. **Ghanaian street foods encountered in the study**

Food	Description	Cooking method	Handling after cooking	Sources of contamination
Koko (porridge)	Fermented maize dough	Boiling	Served with spoon	Equipment, eating bowls
Koose	Fried bean cake	Frying	Served hot	Hands, equipment
Salad	Mixture of fresh vegetables	No cooking	Served with spoon No refrigeration	Fresh vegetables, hands and equipment
Talia (home-made macaroni)	Extruded wheat flour	Boiling	Served with hands	Hands
Fufu	Pounded cassava with plantain, cocoyam or yam	Boiling and pounding	Placed in mortar and pounded with pestle while turning over by hand	Equipment, hands, water
Kenkey	Fermented maize dough dumplings.	Wrapped in corn husk or plantain leaves and boiled	Served hot	Cold water, hands
Akpler, banku	Fermented maize dough dumplings	Heating with continuous stirring	Dumplings made by hand in plate or calabash with cold water	Hands, equipment and cold water
Rice	Boiled rice	Boiling	Dished into bowls and served with spoon and hands	Hands, bowls and spoons.
Gari	Fermented cassava flour	Used dry or cold water added	Served with spoon	Spoon and water
Wankye	Rice and beans	Boiling	Scooped into bowl and served with spoon and hands	Bowls, hands and spoons
Yam and plantain	Boiled or fried	Boiling or frying	Served hot with hands or spoon	Hands and fork
Beans	Cooked beans	Boiling	Served with spoon	Spoon
Fried fish	Fish	Frying	Stored at ambient temperature until sold Served with hand or fork	Prolonged storage, hands, and fork
Light soup	Mixture of tomatoes, onions, pepper, fish or meat, eggs	Boiling	Served while on cooking fire	Vegetables, fish, meat, and serving spoon
Groundnut soup	Same as light soup. Peanut butter added	Idem	Idem	Idem
Okra soup	Same as light soup. Okra and palm oil added	Idem	Idem	Idem
Palm nut soup	Prepared from palm nut puree as above	Idem	Idem	Idem
Tomato stew	Gravy made with onions, tomatoes, pepper and vegetable oil. Fish, meat or chicken used	Stewing	Served with spoon	Idem
Nkontomre (cocoyam leaves) stew	Gravy with palm oil and fish as above. Nkontomre added	Idem	Idem	Idem
Palm nut oil	Oil from palm nuts	Heated	Served with spoon	None
Vegetable oil	Vegetable oil with onion	Idem	Idem	Vegetables
Red pepper	Pepper, onion, tomatoes	Mashing. No heating	Served with spoon	Fresh vegetables
Fried pepper (shito)	Same as above with dried fish and shrimps	Frying	Served with spoon	Prolonged storage, spoon

We have previously studied risk factors for acute and persistent diarrhoea in an urban slum in Accra, Ghana (*3*). About 60% of 951 mothers supplemented their children's diet with street food. The children had an increased risk of both acute and persistent diarrhoea. There were higher levels of contamination in the street food given to these children than in food cooked at home. In the same area we evaluated also the following: the role of street food vendors in the transmission of diarrhoeal pathogens; the microbial quality of street foods; and factors that could predispose food to contamination with bacteria.

We have already published data on the role of street food vendors in the transmission of diarrhoeal pathogens (*4*). In the present paper we report our findings on the microbial quality of street foods and the risk factors for food contamination.

Methods

Data collection

Prior to starting the investigation, we explained its aims to head teachers and representatives of the food vendors in the study area. The street food vendors were recruited into the study after the owners of the vending sites had given their approval and the vendors were assured total confidentiality.

Study population and sample collection

The study was conducted in Nima-Kotobabi-Pig Farm-Accra New Town sub-area. Vendors of street foods in the major streets, markets and two schools were recruited. There were approximately 120 vending sites; the persons in charge of the vending points (subsequently referred to as the vendors) were

the main subjects of study. A structured questionnaire was used to gather data on vital statistics, personal and food hygiene practices and knowledge of foodborne pathogens.

Samples of about 50 g of each food on sale were placed in separate sterile containers and transported to the laboratory on ice within two hours of collection. All samples were examined the same day.

Bacteria counts

Portions of food weighing 10 g were diluted at 1:10 with 90 ml of phosphate-buffered saline (Oxoid Dulbecco A BR 14a, UNIPATH (Oxoid), Basingstoke, England). Further tenfold serial dilutions were made and examined by means of the pour-plate method (*5*–*7*).

Total bacterial counts were made by means of plate count agar (Oxoid CM463). Counts of Enterobacteriaceae, *Staphylococcus aureus*, and *Bacillus cereus* were made using violet red bile lactose agar (Oxoid CM107), Baird–Parker agar (Oxoid CM275) and *B. cereus* selective agar (Oxoid CM617 and SR99), respectively (*5*–*7*). After appropriate incubation, dilutions with 30–300 colonies were selected and counted. The number of colony-forming units per g (cfu/g) of food was calculated by multiplying the number of bacteria by the dilution.

Isolation and identification of Enterobacteriaceae

Portions of food weighing 10 g were inoculated into buffered peptone water (Oxoid CM509) for resuscitation of metabolically injured bacteria. After overnight incubation of the inoculates, the entire buffered peptone water was decanted and centrifuged at 11 000 rpm for 30 minutes in a refrigerated centrifuge (Hitachi 20PR-259, Tokyo, Japan). The deposit was streaked on *Salmonella/Shigella* agar (BBL 11597, BBL Microbiological Systems, MD, USA), xylose–lysine deoxycholate agar (Oxoid CM469) and MacConkey agar (Oxoid CM7) for the detection of *Salmonella, Shigella, E. coli*, and other Enterobacteriaceae.

Portions of the pellet were inoculated into selenite–lactose broth (Eiken 42001, Tokyo, Japan) for selective enrichment of *Salmonella* and *Shigella* and were streaked on *Salmonella/Shigella* agar and xylose–lysine deoxycholate agar for the detection of isolated colonies. All incubations were conducted at 37 °C under aerobic conditions. Suspected colonies were identified using standard biochemical methods. API 20E kits (bio-Mérieux SA, Marcy-l'Étoile, France) were used for further identification. Specific *Salmonella* antisera (O grouping and Vi-sera (Denka Seiken No. 21041, Tokyo, Japan)), *Shigella* antisera (III) (Denka Seiken No. 14530) and *E. coli* (I) O sera (Denka Seiken No. 24506) were used for further typing.

Bacteria identified as *E. coli* were stored individually at –70 °C in tryptic soy broth with 40% (v/v) glycerol. They were tested for heat-labile and heat-stable enterotoxin plasmids by means of DNA–DNA hybridization (*8*). Enteroaggregative *E. coli* were tested using HEp2 tissue culture cells (*9*).

Data handling and analysis

The data were analysed using EpiInfo version 6 software. The values obtained for cfu/g of food were transformed into $\log_{10}$ values. Foods were classified as having no-to-low risk of transmitting pathogenic bacteria if the total count was less than 5.0 $\log_{10}$ cfu/g and if the counts of Enterobacteriaceae, *B. aureus* and *S. aureus* were less than 3.0 $\log_{10}$ cfu/g. A classification of medium-to-high risk corresponded to values of at least 5.0 $\log_{10}$ cfu/g for total counts and of at least 3.0 $\log_{10}$ cfu/g for Enterobacteriaceae, *B. cereus* and *S. aureus*.

Cross-tabulations were made of the levels of the various bacteria tested and the responses obtained in the interviews. The significance of any observed differences was determined using χ^2 test and Student's *t*-test. The Mann–Whitney rank sign test was performed for samples that violated a parametric test. Statistical significance was set at $P \leqslant 0.05$. In order to determine the effect of the knowledge and practices of vendors on the microbial quality of street foods, we calculated confidence intervals after factors and levels of contamination were cross-tabulated.

Results

In Accra the street food trade was conducted by children aged $\geqslant$10 years and by women aged $\leqslant$ 52 years. A total of 38 of the vendors (33.3%) had received no formal education; nevertheless, they exhibited good hygiene behaviour as indicated by the high prevalence of hand-washing and personal care (Table 2). Diarrhoea was defined by 110 (94%) vendors as the passage of three or more stools per day but no vendors associated diarrhoea with bloody stools (Table 3). A total of 21 vendors (17.9%) associated diarrhoea with germs but none was aware that dirty hands were a risk factor for diarrhoea (Table 3).

Table 4 shows that various people bought street foods held in open or protected structures. The surroundings of the vending sites were predominantly clean; only four (3.4%) were classified as very dirty.

Food-handling practices that could affect the microbial quality of street foods are indicated in Table 5 and Table 6. Among these practices were the following: cooking food well in advance of consumption; exposure of food to flies; working with food at ground level; and handling food.

Table 2. **Characteristics of the study street food vendors, Accra, Ghana**

Parameter	Frequency (n = 117)
Age (years)	
<30	41 (35.0)[a]
30–39	41 (35.0)
40–49	23 (19.7)
$\geqslant$50	12 (10.3)
Sex	
Female	117 (100.0)
Male	0
Educational attainment	
Primary school	20 (17.0)
Middle school	41 (35.0)
Secondary/secretarial school	9 (7.7)
Arabic school	7 (6.0)
No education	38 (33.3)
Personal hygiene	
Hands washed at least three times daily	35 (30.2)
Hands washed more than three times daily	81 (69.8)
Hands not washed throughout the day	1 (0.9)
Clean clothes	110 (96.5)
Fingernails cut	103 (92.5)
Hair covered	62 (54.4)

[a] Figures in parentheses are percentages.

Table 3. **Knowledge of diarrhoea exhibited by the study vendors, Accra, Ghana**

Parameter	No. responding correctly
Definition of diarrhoea	
Passage of more than three liquid stools in a day	110 (94.0)[a]
Passage of mucoid stools	7 (6.0)
Passage of bloody stools	0 (0.0)
Transmission of enteric pathogens	
Dirty food	34 (29.1)
Dirty water	8 (6.8)
Dirty hands	0 (0.0)
Cause of diarrhoea	
Germs	21 (17.9)

[a] Figures in parentheses are percentages.

Table 4. **Characteristics of vending sites and customers, Accra, Ghana**

Parameter	*n*
Type of vendor	
Stationary	116 (99.1)[a]
Mobile	1 (0.9)
Type of customer	
Schoolchildren	103 (88.0)
Market women	84 (71.8)
Workers	111 (94.9)
Type of vending site	
Chop-bar (protected)	21 (17.9)
Open air	96 (82.1)
Schools	20 (19.0)
Drinking-water	
Provided	104 (88.0)
Not provided	13 (12.0)
Covered	95 (80.3)
Not covered	9 (7.7)
Vending site hygiene	
Much litter	4 (3.4)
Some litter	67 (57.3)
No litter	31 (26.0)
Litter bin available	15 (12.3)
Stagnant water on ground	11 (9.4)

[a] Figures in parentheses are percentages.

A total of 511 menu items, classified as breakfast/snack foods, main dishes, soups and sauces, and cold dishes were examined for aerobic mesophilic bacteria (total counts), *B. cereus*, *S. aureus* and Enterobacteriaceae. Mesophilic bacteria were identified in 356 food samples (69.7%); and *B. cereus*, *S. aureus* and Enterobacteriaceae were found in 28 (5.5%), 163 (31.9%), and 172 (33.7%), respectively.

Table 7 shows that the microbial quality of most foods was within acceptable limits, i.e. <5.0 $\log_{10}$ cfu/g for total counts, <3.0 $\log_{10}$ cfu/g for Enterobacteriaceae, *S. aureus* and *B. cereus*, and zero tolerance for other pathogens. Samples of salads, macaroni, fufu, omo tuo, and red pepper had unacceptable levels of contamination. *Shigella sonnei* was isolated from macaroni, *Salmonella arizonae* from light soup with meat, and enteroaggregative *E. coli* from macaroni, tomato stew, and rice (Table 8).

Table 5. **Food-handling practices and care of equipment**

Parameter	*n*
Food-handling	
Food cooked well in advance of consumption	46 (39.3)[a]
Food cooked on morning of sale	49 (41.9)
Food cooked during sale	22 (18.8)
Cooked food sold from cooking pot	46 (39.3)
Cooked food scooped into bowls or polythene bags	49 (41.9)
Food sold from mesh protection	32 (27.4)
Food kept on cooking fire during sale	5 (4.3)
Food sold from tray with covering	7 (6.0)
Food sold from tray with no covering	3 (3.6)
Food reheated before sale	22 (18.8)
Food exposed to flies	41 (35.0)
Food handled at ground level	20 (17.1)
Serving of food	
Food served with fork/spoon	80 (68.9)
Food served with bare hands	45 (35.9)
Food served into cup/plate/calabash	26 (22.2)
Food served into paper/leaves	4 (3.4)
Cleaning of crockery	
Water with soapy appearance	59 (40.2)
No soap used	11 (9.4)
Water with oily appearance	47 (40.2)
Water with dirty appearance	57 (48.8)
Clean water used	10 (8.5)

[a] Figures in parentheses are percentages.

Discussion

Despite poor environmental hygiene the street foods were, in general, microbiologically safe (Table 7). Similar results were reported for salads and gravies in Johannesburg (*10*).

Breakfast and snack foods

Breakfast and snack foods, e.g. koko and koose (bean cake), were the least contaminated; only a few samples contained mesophilic bacteria. There were no *B. cereus, S. aureus*, or Enterobacteriaceae in any of these foods. Porridge was prepared in the early hours of the morning and sold within 2–3 hours at 50–90 °C, a temperature range over which most vegetative bacteria do not survive. Most of the porridge samples were prepared from maize dough that had undergone lactic acid fermentation. This traditional food preparation technology produces an environment that inhibits various diarrhoeal pathogens (*11*). The contamination of porridge possibly occurred during serving with a spoon and calabash kept in a bowl of water in which the vendor washed her hands and cleaned cups and eating bowls. Koose was prepared on site by frying at 165–175 °C, a temperature range that kills most bacteria. Koose was served hot, another factor accounting for the relatively low levels of bacteria in this product. If care is taken during serving, microbial quality can be markedly improved.

Main dishes

A large proportion of main dishes was contaminated with unacceptable levels of bacteria: fufu, akpler, rice, and wankye

Table 6. **Summary of factors that could influence food contamination**

Factor	95% Confidence interval
Faults	
Sale of food in schools	– 0.25 to – 0.75
Sale of food at roadside	– 0.48 to – 0.24
Failure to associate diarrhoea with dirty food	– 1.37 to – 0.37
Failure to associate diarrhoea with dirty water	– 1.21 to – 0.55
Scooping of food into large polythene bags after cooking	– 0.37 to – 0.07
Scooping of food into a bowl and keeping in a sieve	– 0.76 to – 0.4
Food exposed to flies	– 0.95 to – 0.69
Handling of food at ground level	– 1.02 to – 0.74
Use of dirty water for washing crockery	0.27 to 1.25
Practices that reduce food contamination	
Cooking food in chop-bar	17 to 0.65
Sale of food at chop-bar	– 1.2 to – 0.18
Knowledge of diarrhoea as passage of three or more loose stools in a day	– 0.37 to – 0.71
Knowledge of diarrhoea as passage of watery or liquid stool	0.48 to – 0.60
Selling food from container used for cooking	0.47 to – 0.25
Food reheated before sale	– 0.73 to – 0.63
Serving food with spoon/fork	0.4 to 1.50
Use of soapy water to wash crockery	0.19 to 0.41

were particularly heavily contaminated. These foods were handled excessively after cooking. The preparation of fufu involved pounding the staple after cooking by means of a mortar and pestle and turning the stiff dough with the bare hands, which were occasionally washed in a container of water. Akpler was rolled into balls after cooking, a process that involved using the hands and a calabash or bowl and water, which were possible sources of contamination of the cooked product. The scooping of rice and wankye into bowls or polythene bags was a major influence in the contamination of these foods, as was demonstrated when microbial levels were cross-tabulated with data relating to this factor (Table 6). Contamination was reduced where vendors sold food from the cooking pots. These findings confirm a previous observation (*12*) that contamination from utensils was possible during serving but not from storage containers, since leftovers were generally stored in the original cooking pots.

Soups and sauces

Soups and sauces appeared to be even more contaminated with enteroaggregative *E. coli*, which were isolated from tomato stew and shito. These are usually prepared the day before consumption. If reheating is inadequate, bacterial contaminants can multiply. Fish and meat can be additional sources of pathogens. Table 8 shows that *Salmonella arizonae* was found in soup. High levels of faecal bacteria and various enteric pathogens have been found in chicken, beef and goat

Table 7. **Mean level of bacterial contaminants in street food, Accra, Ghana**[a]

		Mean $\log_{10}$ cfu/g (ml) ± standard deviation			
Food item	***n***	**Total counts**	**Enterobacteriaceae**	***Staphylococcus aureus***	***Bacillus* spp.**
Koko	12	1.0 ± 1.32	<1	<1	<1
Koose	7	<1	<1	<1	<1
Salad	17	6.3 ± 0.78	4.7 ± 1.22	3.7 ± 1.88	0.4 ± 1.14
Macaroni	26	6.0 ± 1.64	4.6 ± 1.73	4.0 ± 1.62	0.5 ± 1.42
Banku	25	2.3 ± 1.26	0.5 ± 1.46	0.2 ± 0.82	0.1 ± 0.06
Fufu	10	6.2 ± 1.57	4.2 ± 1.56	2.9 ± 1.69	0.4 ± 1.19
Gari (dry)	18	2.2 ± 1.80	0.3 ± 1.31	<1	<1
Gari (wet)	19	4.4 ± 2.26	2.2 ± 2.45	0.8 ± 1.70	<1
Kenkey	15	0.8 ± 1.69	0.3 ± 1.30	<1	<1
Omo tuo	6	5.4 ± 0.79	4.3 ± 0.84	2.6 ± 2.08	<1
Kokonte	9	4.1 ± 2.41	0.5 ± 1.47	2.01 ± 1.98	0.9 ± 1.8
Wankye	20	3.3 ± 1.80	1.0 ± 1.43	2.0 ± 2.04	0.5 ± 1.33
Yam	10	3.5 ± 2.06	1.8 ± 1.71	1.1 ± 1.94	0.9 ± 1.56
Plantain	15	2.7 ± 2.11	0.6 ± 1.70	0.9 ± 1.88	<1
Rice	22	2.9 ± 2.28	1.5 ± 2.04	1.3 ± 1.94	0.2 ± 0.91
Beans	20	2.5 ± 0.03	0.7 ± 1.46	0.6 ± 1.19	<1
Fried fish	28	4.6 ± 2.04	2.0 ± 2.24	3.1 ± 2.17	<1
Groundnut soup	13	1.4 ± 2.05	0.4 ± 1.37	0.3 ± 1.00	<1
Nkontomre stew	12	2.0 ± 2.85	0.3 ± 0.92	0.3 ± 1.18	0.3 ± 1.14
Light soup	12	0.3 ± 0.88	<1	<1	<1
Okra soup	23	3.8 ± 2.64	1.1 ± 2.25	1.3 ± 2.14	0.7(1.44)
Oil (red)	15	2.1 ± 2.37	0.9 ± 1.69	0.7 ± 1.76	<1
Palm soup	25	2.2 ± 2.31	0.8 ± 1.70	0.6 ± 1.44	0.2 ± 0.81
Red pepper	19	5.1 ± 1.73	2.7 ± 2.27	1.7 ± 2.05	<1
Shito	35	3.0 ± 2.20	0.8 ± 1.70	1.1 ± 1.90	<1
Tomato stew	40	2.5 ± 2.32	0.9 ± 1.71	1.1 ± 1.81	0.3 ± 0.99

[a] Data refer to foods of which at least five samples were tested.

Table 8. **Enterobacteriaceae isolated from foods, Accra, Ghana**

Food	Bacteria isolated
Koko	*Chryseomonas luteola*
Macaroni	*Shigella sonnei, Pseudomonas fluorescens/putida, Klebsiella pneumoniae, Enterobacter sakazakii, Escherichia coli* (enteroaggregative diffuse), *Citrobacter freundii, Serratia liquefaciens, Enterobacter cloacae, Enterobacter agglomerans, E. coli, Citrobacter diversus/amalonatica, Citrobacter* spp., *Proteus mirabilis, Proteus* spp., *Enterobacter amnigenus, Pseudomonas cepacia*
Salad	*Pseudomonas aeruginosa, S. liquefaciens, E. sakazakii, E. cloacae, P. fluorescens/putida, C. freundii, E. coli, C. diversus/amalonatica*
Shito	*Klebsiella cloacae, K.. pneumoniae, E. cloacae, E.coli*
Tomato stew	*C. freundii, E. sakazakii, E.coli* (enteroaggregative localized)
Nkontomre stew	*E. cloacae*
Fish	*C. diversus, E.coli, C. luteola, P. fluorescens/ putida, E. sakazakii, C. diversus/amalonatica, K. pneumoniae*
Palm nut soup	*C. freundii, E. cloacae*
Groundnut soup	*C. freundii*
Light soup (meat)	*Salmonella arizonae*
Okra soup	*E. cloacae*
White oil	*Pseudomonas* sp.,
Red oil	*Escherichia hermanii, C. freundii*
Red pepper	*K. pneumoniae, S. liquefaciens, Kluyvera* spp., *E. cloacae, E. amnigenus, Citrobacter* sp.
Beans	*C. freundii, K. pneumoniae, E. cloacae*
Kenkey	*Pseudomonas* sp.
Gari	*C. freundii, E. cloacae, C. luteola, Serratia funtida, Enterobacter aerogenes, Enterobacter agglomerans*
Rice	*E.coli (enteroaggregative diffuse), Serratia marcescens, K. pneumoniae, P. fluorescens/putida*
Yam	*C. freundii, K. pneumoniae, Citrobacter* sp, *C. luteola*
Plantain	*Citrobacter* sp., *K. pneumoniae, Acinetobacter* sp., *Klebsiella* sp., *Enterobacter* sp, *C. freundii*
Fufu	*C. diversus, E. cloacae, E. sakazakii,*
Wankye	*Enterobacter, Acinetobacter* sp., *Erwinia* sp., *E. cloacae, K. pneumoniae*
Akpler/banku	*E. cloacae, K. pneumoniae*

meat (*13, 14*). The preparation of food long before its consumption, storage at ambient temperature, inadequate cooling and reheating, contaminated processed food, and undercooking were identified as the key factors in the handling of food that contributed to food poisoning outbreaks in England and Wales (*14*).

A wide range of menu items including formula foods, milk, soups and stews were examined in Peru (*15*), and levels of 0–9.0 $\log_{10}$ cfu/g of food reported. The proportion of contaminated infant foods was 11/66 (16.6%) (5.0–9.0 $\log_{10}$ cfu/g), while 4/221 (1.8%) of soups and stews, had similar levels of bacteria of the type indicating faecal contamination. Other ingredients, e.g. vegetables, were also possible sources of bacterial contaminants since vendors often used cheap supplies in order to maximize their profits. Inadequate cooking results in the survival of bacterial pathogens; cooking utensils can also add to the bacterial load.

Sauces, such as red pepper sauce, are made from fresh vegetables and eaten without having been heated. All bacteria introduced in the ways indicated above survive and multiply if held for prolonged periods at ambient temperature.

Macaroni and salads

Macaroni and salads carried the greatest risk of transmitting diarrhoeal pathogens. In general, bacterial counts were high in the foods, and *Shigella sonnei* and pathogenic *E. coli* were isolated from macaroni. This was not unexpected because, after cooking, tomato stew was stirred into the macaroni. Serving was performed using bare hands as this food was slippery and the use of a spoon or fork might have been difficult. The consumption of pansit (rice noodles with shrimps, meat and vegetables), a similar street food, has been associated with cholera in Manila (*16*).

The high levels of contaminants in salads were not unexpected. In Ghana all types of water are used for watering vegetables, especially those grown in the cities where there are not many natural bodies of water. *Shigella flexneri* and *E. coli* have been isolated from lettuce in Accra (*17*). Lettuce and tomatoes were contaminated with faecal bacteria, *Salmonella* and *Shigella*. Animal waste, e.g. chicken droppings, was used as manure for these vegetables (*18*). These findings call for a careful analysis of events occurring before crops are planted, of production and of packaging and the distribution of fresh produce, as well as of the preparation and sale of street foods.

Risk factors

The use of a fork or spoon to serve food reduced the level of contamination, while the use of bare hands resulted in an increase. Both spoons and bare hands were used to serve rice and wankye. Indeed, 36% of vendors served food with their bare hands. Vendors were carriers of a variety of bacterial enteropathogens, including *Salmonella typhi* (*4*). Defective personal hygiene can facilitate the transmission of these pathogens via food to humans. The serving stage is a critical point in the street food industry.

Enteropathogens can survive on the hands for three hours or longer. Diarrhoeal pathogens on the hands of mothers can be transmitted to infants (*3*). *E. coli* was detected in hand washings of high-income and low-income mothers in India at levels of 7.0 $\pm$ 4.2 $\log_{10}$ cfu/ml and 9.0 $\pm$ 5.7 $\log_{10}$ cfu/ml, respectively (*19*). In Peru, *E. coli* was detected in 11 of 78 mothers' hand washings (*15*). In Thailand, enterotoxigenic *E. coli* (ETEC) was detected in 6 of 42 mothers' hands and in 50 of 37 children's hands. The samples were from homes where children were suffering from ETEC diarrhoea. In most instances the type isolated from diarrhoea cases corresponded to that isolated from hands (*20*).

The present study identified a number of factors that could reduce the risk of contamination (Table 6). An example is the sale of food in chop-bars. These are usually wooden structures, which may be completely or partially enclosed. There is an area for food preparation, and most foods sold in these facilities are freshly prepared or reheated.

That food sold in schools carried the highest risk of transmitting bacteria was cause for concern. A study on foods sold in Nigerian schools showed unacceptable levels of bacteria (*21*). In addition *E. coli* and *S. flexneri* were isolated from some samples. Vendors appeared to be selling substandard food to schoolchildren because of their low

purchasing power and their lack of knowledge on food safety. Children were also more interested in satisfying their hunger than in the quality of the food sold to them.

A lack of knowledge of the definition and causes of diarrhoea were important risk factors. None of the vendors associated dirty hands with the transmission of diarrhoeal pathogens. This explained why people commonly used their hands to serve cooked food. The container in which the food was served was also important and the use of paper and leaves increased the risk of contamination. The paper used for holding food was usually newsprint of questionable origin. Leaves were wiped with a piece of cloth and there was no disinfection. Clearly, the possibility existed that microflorae on leaves and microbes acquired through poor handling were transferred to foods.

Certain risk factors might not have been directly linked to food preparation. Environmental hygiene and the vendor's appearance did not show any significant relationship with the levels of contamination, implying that there was no risk if direct contact could not be made with food. In this connection it should be noted that the handling of food at ground level increased the risk of contamination because dust could easily be blown on to food thus handled. Pathogens can be passed mechanically by flies (*22*). *Salmonella typhimurium* and *Shigella* can multiply in the gut of the housefly and can be excreted for weeks or longer (*22*). There is consequently a risk of contamination associated with the exposure of food to flies (Table 6).

The use of soap to wash utensils and crockery reduced the levels of bacteria. Gram-negative bacilli such as *S. typhi* are fairly susceptible to soap made from saturated fatty acids but resistant to soap made from unsaturated fatty acids. Most microorganisms die after coming into contact with soap but their susceptibilities vary. For example, the vegetative cells of *Bacillus mesentericus* are inhibited within 20 sec of exposure but *S. aureus* survives for 20 minutes (*23*).

An epidemiological link between street foods and diarrhoea has been reported (*3*, *24*, *25*). Certain foods sold by street vendors, e.g. poultry, pork, beef, fish and rice, have been implicated in food poisoning outbreaks (*26–28*).

Conclusions

Our findings indicate the need for stricter implementation of the food sanitation code and the licensing of street food vendors. Public health authorities should intensify efforts to monitor conditions of sanitation and hygiene in establishments serving food and drink to the public.

The public, and, in particular, consumer organizations, could play key roles in the food control system by calling attention to deficiencies and constructively supporting national food quality control systems. Wherever consumer pressures exist there is heightened awareness of food problems and both the authorities and the food industry are under pressure to make improvements.

The street food traders in Accra are mainly women. They could play major roles in food control programmes. Women in Africa, Asia and other parts of the world are involved in a wide variety of food-processing activities. They are also charged with the responsibility of providing food for their households. The success of any food control programme depends on women, since the transfer and implementation of ideas takes place through them (*4*).

In the present study, however, there was a high illiteracy rate (33.3%) among women working as street food vendors (Table 2 and Table 3). Their educational level appeared not to affect their knowledge of the definition of diarrhoea but was strongly associated with knowledge of the mode of transmission of enteric pathogens. The education of these women (*29*) by means of messages based on our findings is essential in programmes aimed at improving the microbial quality of street foods. Special attention should be given to the following: causes of diarrhoea; transmission of diarrhoeal pathogens; handling of food after cooking and of equipment used for cooking and serving; hand washing; use of soap; and environmental hygiene. Action along these lines can be expected to improve the safety of street foods and thereby to heighten consumer protection (*30*). ■

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Résumé

La nourriture vendue dans les rues à Accra au Ghana présente-t-elle un danger pour la santé ?

Objectif Etudier la qualité microbiologique de la nourriture vendue dans les rues à Accra ainsi que les facteurs prédisposant à la contamination microbienne.

Méthodes Des données ont été recueillies auprès de 117 vendeurs des rues à l'aide de questionnaires structurés portant sur l'état civil des personnes interrogées, leur hygiène personnelle et leur connaissance des maladies d'origine alimentaire. Des méthodes normalisées ont été utilisées pour le dénombrement, l'isolement et l'identification des bactéries.

Résultats La plupart des vendeurs étaient éduqués et avaient une hygiène satisfaisante. La diarrhée a été définie par 110 vendeurs (94 % de l'échantillon) comme étant un nombre de selles égal ou supérieur à trois par jour mais aucun n'a associé la diarrhée à la présence de sang dans les selles : 21 seulement (17,9 %) ont fait le lien entre la diarrhée et une infection bactérienne. D'une manière générale, les lieux de vente étaient propres mais quatre d'entre eux (3,4 %) ont été classés comme très sales. La préparation des mets longtemps à l'avance,

l'exposition aux mouches, et le fait de manipuler les aliments au ras du sol et à main nue ont été identifiés comme des facteurs de contamination potentiels. Des études ont été effectuées sur 511 mets se répartissant entre aliments pour le petit déjeuner ou pour la collation, plats principaux, soupes et sauces et plats froids. Des bactéries mésophiles étaient présentes dans 356 échantillons (69,7 %) : *Bacillus cereus* a été isolé dans 28 d'entre eux (5,5 %), et *Staphylococcus aureus* dans 163 (31,9 %). Cent soixante douze échantillons (33,7 %) contenaient des entérobactéries. La qualité microbiologique de la plupart des aliments restait dans des limites acceptables, mais des échantillons de salade, de macaroni, de foufou, d'omo tuo et de piment rouge présentaient des niveaux de contamination excessifs. Des souches de *Shigella sonnei* et d'*Escherichia coli* entéroaggrégatif ont été isolées dans des macaronis, du riz et des préparations à base de tomate et *Salmonella arizonae* a été mis en évidence dans de la soupe claire.

Conclusion Les aliments vendus dans la rue peuvent être des sources d'entéropathogènes. Les vendeurs devraient recevoir une formation en hygiène alimentaire. Une attention particulière devrait être accordée à toutes les causes de diarrhée, aux mécanismes de transmission des pathogènes diarrhéiques, à la manipulation des ustensiles et des aliments cuits, au lavage des mains et à l'hygiène du milieu.

Resumen

Estudio de la inocuidad de los alimentos de venta callejera en Accra, Ghana

Objetivo Se evaluaron la calidad microbiana de los alimentos vendidos en las calles de Accra y los factores que favorecían su contaminación.

Métodos Se usaron cuestionarios estructurados para reunir datos de 117 vendedores callejeros respecto a sus estadísticas vitales, higiene personal, higiene alimentaria y conocimiento de las enfermedades transmitidas por los alimentos. La enumeración, el aislamiento y la identificación de las bacterias se llevaron a cabo empleando métodos estándar.

Resultados La mayoría de los vendedores poseían estudios y mostraban un buen comportamiento higiénico. En total 110 vendedores (94,0%) definieron la diarrea como la evacuación de $\geqslant$ 3 heces al día, pero ninguno asoció la diarrea a la presencia de heces sanguinolentas; sólo 21 (17,9%) asociaban la diarrea a la presencia de gérmenes. Los alrededores de los sitios de venta estaban limpios, pero cuatro de los sitios (3,4%) fueron clasificados como muy sucios. La cocción de los alimentos mucho antes de su consumo, su exposición a las moscas y el hecho de manipularlos a nivel del suelo y con las manos eran factores de riesgo frecuentes de contaminación. Se examinaron 511 artículos, clasificados como desayuno/aperitivo, platos principales, sopas y salsas, y platos fríos. Se detectaron bacterias mesofílicas en 356 alimentos (69,7%): 28 (5,5%) contenían *Bacillus cereus*, 163 (31,9%) *Staphylococcus aureus* , y 172 (33,7%) enterobacterias. La calidad microbiana de la mayoría de los alimentos entraba dentro de lo aceptable, pero diversas muestras de ensaladas, macarrones, fufu, omo tuo y pimentón picante presentaban niveles inadmisibles de contaminantes. Se aislaron *Shigella sonnei* y *Escherichia coli* enteroagregativa a partir de macarrones, arroz y guiso de tomate, y *Salmonella arizonae* a partir de muestras de sopa ligera.

Conclusión Los alimentos de venta callejera pueden ser fuente de enteropatógenos, de ahí la necesidad de enseñar a los vendedores nociones de higiene alimentaria. Se debe prestar especial atención a las causas de diarrea, la transmisión de patógenos diarreicos, el manejo del equipo y los alimentos cocinados, las prácticas de lavado de manos y la higiene del medio.

References

1. *The role of food safety in health and development. Report of the Joint FAO/WHO Expert Committee on Food Safety.* Geneva: World Health Organization; 1983.
2. *Background paper: Developing a food safety strategy.* WHO Strategic Planning Meeting. Geneva: World Health Organization 2001.
3. Mensah P. *Persistent diarrhoea in Ghana.* (Report submitted to Japan International Cooperation Agency; 1997).
4. Mensah P, Owusu-Darko K, Yeboah-Manu D, Ablordey A, Nkrumah FK, Kamiya H. The role of street food vendors in the transmission of enteric pathogens. *Ghana Medical Journal* 1999;33:19-29.
5. Harrigan FW, McCance ME. *Laboratory methods in food microbiology.* London: Academy Press;1968.
6. Thatcher PS, Clark DS. *Microorganisms in foods: their significance and methods of enumeration.* Volume 1. Toronto: University of Toronto Press; 1968.
7. Balows A,Hausler WJ Jr., Herrmann KL, Isenberg HD, Shadomy HJ editors. *Manual of clinical microbiology.* Washington (DC): American Society of Microbiology; 1991.
8. Tamatsukuri S, Yamamoto K, Shibata S, Leano F, Honda T, Miwatani T. Detection of heat-labile enterotoxin gene in enterotoxigenic *Escherichia coli* by densitometric evaluation using highly specific enzyme-linked oligonucleotide probes. *European Journal of Infectious Diseases* 1991;10:1048-55.
9. Nataro JP, Kaper JB, Robins-Browne R, Prado V, Vial P, Levine MM. Patterns of adherence of diarrheagenic *Escherichia coli* to HEp-2 cells. *Paediatric Infectious Diseases Journal* 1987;6:829-31.
10. Kubheka LC, Mosepye FM, von Holy A. Microbial survey of street-vended salad and gravy in Johannesburg City, South Africa. *Food Control* 2001;12:127-31.
11. Mensah P, Tomkins AM, Drasar BS, Harrison TJ. Antimicrobial effect of fermented Ghanaian maize dough. *Journal of Applied Bacteriology* 1991;70:302-10.
12. Desmarchelier PM, Apiwathnasom C, Vilainerun D, Watson C, Johan MR, Ahmad Z, et al. Evaluation of safety of domestic food preparation in Malaysia. *Bulletin of the World Health Organization* 1994;72:877-84.
13. Sackey BA, Mensah P, Collison E, Sakyi-Dawson E. *Campylobacter, Salmonella, Shigella* and *Escherichia coli* in live and dressed poultry from metropolitan Accra. *International Journal of Food Microbiology* 2001;71:21-8.
14. Roberts D. Factors contributing to outbreaks of food poisoning in England and Wales 1970-1979. *Journal of Hygiene* 1982;89:491-8.
15. Black RE, Lopez de Romana G, Brown KH, Bravo N, Bazalar OG, Kanashiro HC. The incidence and etiology of infantile diarrhea and major routes of transmission in Huascar, Peru. *American Journal of Epidemiology* 1989;189: 785-99.
16. Lim-Quizon MC, Benabaye RM, White FM, Dayrit MM, White ME. Cholera in metropolitan Manila: foodborne transmission via street vendors. *Bulletin of the World Health Organization* 1994;72:745-9.
17. Kotoku EK. *Health hazards (microbiological) associated with salad (lettuce) purchased from street stalls in Accra* [dissertation]. Legon: University of Ghana; 1978.
18. Mensah P, Armar-Klemesu M, Hammond AS, Haruna A, Nyarko R. Bacterial contaminants in lettuce, tomatoes, beef and goat meat from metropolitan Accra. *Ghana Medical Journal* 2001;35:1-6.
19. Mathur R, Reddy V. Bacterial contamination of infant foods. *Indian Journal of Medical Research* 1983;77:342-6.

20. Echeverria P, Taylor DN, Seriwatana J, Leksomboon U, Chaicumpa W, Tirapat C, et al. Potential sources of enterotoxigenic *Escherichia coli* in homes of children in Thailand. *Bulletin of the World Health Organization,* 1987;65:207-15.
21. Olukoya DK, Bakare SB, Abayomi O. Microbiological evaluation of food samples sold to primary school children in Lagos, Nigeria. *Journal of Tropical Paediatrics* 1991;37:266.
22. Levine OS, Levine MM. Houseflies (*Musca domestica*) as mechanical vectors of shigellosis. *Reviews of Infectious Diseases* 1991;13:688-96.
23. Bannan EA, Judge LF. Bacteriology studies relating to hand washing. The inability of soap bars to transit bacteria. *American Journal of Public Health* 1965;55:915-22.
24. Heinze JE, Yackovich F. Washing with contaminated bar soap is unlikely to transfer bacteria. *Epidemiology and Infection* 1988;101:135-42.
25. Ericsson CD, Pickering LK, Sullivan P, DuPont HL. The role of location of food consumption in the prevention of travellers' diarrhoea in Mexico. *Gastroenterology* 1980;79:812-916.
26. Tjoa WS, DuPont HL, Sullivan P, Pickering LK, Holguin AH, Olarte J, et al. Location of food consumption and travellers' diarrhoea. *American Journal of Epidemiology* 1977;106:61-6.
27. El-Sherbeeny MR, Saddik MF, Bryan FL. Microbiological profile of foods served by street vendors in Egypt. *International Journal of Food Microbiology* 1985;2:355-64.
28. Jiwa SF, Krovacek K, Wadstrom T. Enteropathogenic bacteria in food and water from an Ethiopian community. *Applied and Environmental Microbiology* 1981;41:1010-9.
29. Umoh VJ, Odoba MB. Safety and quality evaluation of street foods sold in Zaria, Nigeria. *Food Control* 1999;10:9-10.
30. Abdussalam M, Kaferstein FK. Safety of street foods. *World Health Forum* 1993;14:191-4.