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THE GHANAIAN CURRENCY NOTES AND COINS: A MEDIUM OF EXCHANGE FOR PATHOGENIC MICROBES

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ABSTRACT

The microbial load of the "old" and "new" Ghanaian Cedi notes and coins obtained from various sources in Cape Coast, Ghana was studied using the dilution plate technique between September 2005 - March 2006 and September 2008 - March 2009. Isolations were made on MacConkey agar for coliforms and other enteric bacteria, Plate Count agar for total viable bacteria and Sabouraud agar for fungi. Generally, the notes carried significantly higher microbial loads than the Cedi coins ($p < 0.001$). Yeasts were the dominant microorganisms on both banknotes and coins, followed by moulds and coliform bacteria were the least. The enteric bacteria isolated were of the lactose-fermenting (coliforms) and non lactose-fermenting types. The presence of coliforms on the banknotes and coins indicated faecal contamination and thus implicated poor hygienic practices involved in the handling of Ghanaian currency notes and coins. The sources of collection of the banknotes and coins seemed to determine the types and population of microorganisms on the notes and the coins. There was however no significant difference ($p>0.05$) between bacterial loads isolated from the "old" notes and coins on one hand and "new" Cedi notes and coins on the other hand suggesting that the Ghanaian currency notes and coins were being mishandled by majority of the populace. The presence of various types of bacteria and fungi on the "Cedi" notes and coins suggests that they may act as vehicles for pathogens of some communicable diseases.

INTRODUCTION

Infectious diseases, the leading cause of death worldwide are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi. They can be spread, directly from one person to another or from animals to humans or indirectly through food, water or many other inanimate objects scientifically referred to as formites. These routes of transmission are of great importance in the health of many populations where the frequency of infection is a general indication of local hygiene and environmental sanitation levels (Cooper, 1991). Banknotes and coins represent formites which can become contaminated with infectious agents emanating from the atmosphere, dust, dirt or droplets resulting from coughing or sneezing, as they are passed on from hand to hand.

Everyday, cash money in the form of notes and coins is passed on from one person to another

for the payment of goods or services, for settlement of debts, or for deferred payment in economic activities. The Bank of Ghana periodically issues Cedi notes and coins for the payment of goods and services. As at 2006, the coins used were as follows: ¢50.00, ¢100.00, ¢ 200.00 and ¢500.00 while banknotes were ¢ 1,000.00, ¢2,000.00, ¢5,000.00, ¢10,000.00 and ¢20,000.00. All these are now commonly referred to as "old" Ghana cedi notes and coins. With the redenomination of the Ghana Cedi on July 1, 2007 however, the "new" Cedi coins and notes are respectively listed as follows: 1 Ghana pesewa (Gp), Gp5, Gp10, Gp50, GH¢ 1.00 and GH ¢ 1. 00, GH¢ 5. 00, GH ¢10.00, GH¢20.00, GH¢50.00.

In Ghana and most developing countries, banknotes and coins are extensively mishandled by various categories of people during transactions. A great majority of the populace does not carry money in wallets, and squeezing currency notes is a common occurrence (Lamichhane *et al*., 2009; Awe *et al*., 2010; Feglo and Nkansah, 2010). Furthermore, a lot of cash money circulates outside banks. Money is often stored especially among the unenlightened in pockets, brassieres, waist pouches, handkerchiefs and socks, where it gets wet and dirty with sweat resulting in the characteristic smelly and soiled nature of abused Cedi notes. It is quite unfortunate that despite the efforts made by the Bank of Ghana to educate the public on good handling practices of cash money, people's attitude seems not to have changed. The dirty and smelly nature of Cedi notes might be an indication that they carry some microorganisms.

Money on which pathogenic microorganisms might survive represents an often overlooked reservoir for enteric diseases (Michaels, 2002). Studies carried out in both developed and developing countries revealed that banknotes and coins are often contaminated with a variety of infectious agents rendering harmful to health the handling of cash money (Abrams and Waterman, 1972; Micheals, 2002; Pope *et al*., 2002; Dey, 2003; Siddique, 2003; Basavarajappa *et al*., 2005; Xu *et al*., 2005; Barro *et al*., 2006; Hosen *et al*., 2006; Oyero and Emikpe, 2007; Uneke and Ogbu, 2007; Umeh *et al*, 2007; Prasai *et al*, 2008; Lamichhane *et al*., 2009; Kawo *et a*l., 2009; Awe *et al*., 2010; Matur *et al*., 2010; Okungbowa and Dede, 2010). Though a lot of research has been conducted elsewhere on the microbial status of currency notes and coins, scanty information on the microbial load of the Ghanaian currency is available.

Despite the fact that the "old" Cedi notes and coins are no more in use in Ghana, a study on their microbial status appears to be crucial as it forms a basis of comparison of attitude in handling Ghanaian currency notes and coins. Since its introduction in July 2007, the "new" Ghanaian Cedi notes and coins appeared to have been extensively transacted. It therefore becomes necessary to investigate the extent to which they are contaminated with microorganisms and compare these loads to those of the "old" Cedi notes and coins. Despite the impressive growth of financial institutions in Ghana, there are still a lot of people without any bank account. Until public education is intensified and more people are encouraged to save in banks, with a greater number of our notes and coins still in circulation, contamination would be unavoidable. It is for this reason that we undertook this study to investigate the incidence and load of microbes on both old and new Ghana Cedi notes and coins.

MATERIALS AND METHODS

Study area and target group

The study was conducted in the Cape Coast Metropolis between September 2005 - March 2006 and September 2008 - March 2009. Ghana currency notes and coins were obtained from various sources including porridge sellers, roasted plantain sellers, sachet water sellers, butchers, fresh fish sellers, chop bar operators, Intercity State Transport Company (STC) station washroom care-takers, taxi drivers and banks.

Sample collection

Sterile translucent polythene bags were used for

the collection of samples from the various sources. Microbiological media used during the isolation of micro-organisms include MacConkey Agar (Biotec. Laboratories Ltd.), Plate Count Agar (Merck, Germany), Sabouraud Agar and Quarter-strength Ringer's solution (Harrigan and McCance, 1966).

The snowball method of sampling was employed in this study. Cedi notes and coins sampled were obtained from all but one of the various sources by purchasing an item or paying for a service using a large-denomination note. This created the need for a change to be given at each sampling time. Fresh Cedi mints of vari- ous denominations were also obtained from the Ghana Commercial Bank, University of Cape Coast Branch, and served as controls. Samples collected from all the sources were directly put into sterile polythene bags which were sealed and immediately transported to the biotechnology laboratory of the Department of Molecular Biology and Biotechnology of the University of Cape Coast for examination and further analysis.

Physical examination

The dates of manufacture of both the coins and the notes were recorded. Cedi notes and coins sampled were categorized based on their physical conditions as mint, fairly clean, dirty/ mutilated. The term mint connotes Cedi notes and coins that had been recently produced and freshly obtained from the bank. These notes and coins were included in the study and served as controls. Cedi notes that were considered fairly clean, exhibited a clean appearance without any obvious damage while those that were considered dirty/ mutilated appeared to have a number of aberrant features. Thus in this study, Cedi notes that appeared to be stinking, perforated or torn with or without the pieces joined together with sellotape, one or more of the angles cut-off, wet or soaked, , soiled/ stained with blood or other body fluids, powdery substances such as pepper; were generally referred to as dirty or mutilated. Similarly, fairly clean coins appeared to be relatively clean and shiny while coins that were considered dirty/ mutilated were dull in appearance and had accumulated dirt on either one of both faces.

Media preparation and collection of inoculum

All media were prepared according to the manufacturer's instructions.

Inoculum collection was achieved using the rinse method (Harrigan and McCance, 1966). Banknotes and coins collected from each source were aseptically and individually transferred into additional sterile polythene bags with the aid of sterile forceps. All these polythene bags were labelled accordingly before the addition of 20 ml of sterile quarter-strength Ringer's solution. The polythene bags were then sealed and allowed to stand for 1 hour at room temperature (27±1^{o}C) with regular shaking to dislodge the cells in to suspension. The rinse solutions or suspensions obtained were used for subsequent analysis.

Inoculation using the rinse solutions

The pour-plate method using 1ml-volume of inoculum was adopted and serial dilutions were made (Harrigan and McCance, 1966). MacConkey Agar, Plate Count Agar, Sabouraud Agar were used to enumerate coliforms, total bacteria and fungal populations respectively on the Cedi notes and coins. The inoculated Petri plates were incubated at 35 ^{o} C for 12 – 18 hours for bacteria and at room temperature (27±1^{o}C) for 4 – 7 days for fungi.

Colony counts and identification

The various experiments were conducted in triplicates. The colonies that grew on the Petri plates after the incubation period were counted and the mean colony forming units (CFU) for each Cedi note or coin estimated. Bacterial isolates were identified based on colony morphology on the medium used, Gram stain reaction and microscopy, while fungal colonies were identified based on colony characteristics and identification manuals (Benson, 1998; Cheesbrough, 1998).

Estimation of total microbial load per unit area of the cedi notes and coins

The microbial load of each Cedi note or coin in the total volume of the rinse solution or washings (20 ml) was computed as follows:

Microbial load per unit area

$$= \frac{\text{CFU/ml of working} \times 20\text{ml}}{\text{Total surface area of banknote or coin}}$$

where CFU = Colony Forming Unit

The computation of the total surface area of the various Cedi notes and coins is shown in Table 13.

Statistical analysis

The relationships between variables and proportions were assessed by Chi-square analysis and analysis of variance (ANOVA) using Minitab 15 and (LSD) test. In all cases a p-value <0.05 was considered statistically significant.

RESULTS

A total of 260 pieces of both "old" and "new" Bank of Ghana Cedi notes and 102 pieces of both "old" and "new" Bank of Ghana Cedi coins were sampled. The date of issue of all the "old" Cedi notes involved in this study surprisingly was 4th August 2003 while that of the "old" Cedi coins was either 1997 or 1998. All the "new" Cedi notes and coins examined had been issued on the 1st July 2007. The physical examination carried out prior to the screening for bacterial and fungal contaminants on both "old" and "new" Cedi notes and coins revealed that all Cedi notes and coins obtained from the bank were mint while those obtained from the other sources were either fairly clean or dirty/ mutilated (Table1 and Table 2). Data analysis revealed that there was a highly significant (χ^2 = 681.679, p<0.001) difference among the total bacterial counts isolated from all "old" Cedi notes collected from the various sources and the same applied to the coliform loads (χ^2 = 186.712, p < 0.001) isolated from all "old" Cedi notes collected from the same sources with the highest loads obtained from fresh fish sellers and butchers and the least from sachet water sellers (Table 3). A similar trend was observed for the "new" Cedi notes with respect to both the total bacterial and coliform loads (χ^2 = 776.1, p <0.001 and χ^2 = 127.2, p <0.001 respectively) (Table 4). The Cedi notes generally carried higher loads than the Cedi coins. Isolations made on MacConkey agar irrespective of the source of collection of Cedi notes and coins revealed the presence of both lactose fermentors and non-lactose fermentors. Contrary to the Cedi notes, there was no significant (χ^2 = 7.736, p > 0.05) differences between the total bacterial loads isolated from the "old" Cedi coins obtained from various sources (Table 5). Likewise, there was no significant (χ^2 = 8.821, p > 0.05) differences between the coliform counts isolated from all "old" Cedi coins sampled from various sources (Table 5). Similar observations were made on the "new" Cedi coins with no significant (p > 0.05) differences (Table 6).

Various fungal isolates were obtained including moulds and yeasts. Further analyses revealed that there was highly significant (p < 0.001) differences between the various fungal loads isolated from the various occupational groups. The commonest fungi isolate from both "old" and "new" notes and coins were yeast followed by *Penicillium* sp. and *Aspergillus niger* and *Rhizopus* sp. the least common. Additionally among all the "new" and "old" notes collected from the various occupational groups, Cedi notes collected from the butchers and fresh fisher sellers were found to carry the highest fungal populations and those collected from sachet water sellers carried the least fungal populations (Tables 7 and 8). Fungal populations isolated from coins obtained from the various occupational groups, were found not to be significantly (p > 0.05) different (Table 9 and 10). Table 11 and 12, respectively show a comparison between the "old" and "new" Cedi notes and coins with respect to total bacterial and coliform loads isolated. It was also observed that there was no significant (p > 0.05) differences between these counts. No isolations were made from all mint Cedi notes and coins.

DISCUSSION

In as much as this study was aimed at determining the microbial load of the "old" and "new" Cedi notes and coins as an indicator of behavioural change in the handling of cash money, the results obtained confirm to a greater extent studies conducted in different parts of the world that have reported high levels of contamination of currency notes and coins in circulation (Talaro and Talaro, 1996; Dey, 2003; Siddique, 2003; Basavarajappa *et al*., 2005; Barro *et al*., 2006; Oyero and Emikpe, 2007; Umeh *et al*, 2007; Uneke and Ogbu, 2007; Prasai *et al*, 2008; Kawo *et al.,* 2009; Feglo and Nkankah, 2010; Lamichhane *et al*., 2009; Awe *et al*., 2010; Matur *et al*., 2010; Okungbowa and Dede, 2010). The date of manufacture of all "old" and "new" Cedi notes sampled suggest that they had been in circulation for about two to three years. Approximately 51% of all banknotes examined were dirty/ mutilated while the rest were found to be fairly clean. Due to the

Table 1: Sources and description of Bank of Ghana "old" and "new" Cedi notes collected between the hours of 7:30am and 9:30 am at each sampling time

Sources of collection	Type of Cedi	Total number examined	Number of Cedi notes examined with specific physical conditions		
			Mint	Fairly clean	Dirty/Mutilated
Porridge sellers	Old	14	0 (0.00)	8 (57.14)	6 (42.86)
	New	9	0(0.00)	5 (55.55)	4 (44.45)
Fresh fish sellers	Old	21	0 (0.00)	8 (38.09)	13 (61.91)
	New	28	0 (0.00)	11 (39.29)	17 (60.71)
Sachet water sellers	Old	10	0 (0.00)	4 (40.00)	6 (60.00)
	New	12	0 (0.00)	4 (33.33)	8 (66.67)
Butchers	Old	23	0 (0.00)	7 (30.44)	16 (69.56)
	New	17	0 (0.00)	8 (47.05)	9(52.95)
STC station washroom	Old	15	0 (0.00)	7 (46.66)	8 (53.34)
	New	8	0 (0.00)	5 (62.50)	3 (37.50)
Taxi drivers	Old	12	0 (0.00)	7 (58.33)	5 (31.67)
	New	13	0 (0.00)	5 (38. 46)	8 (61.54)
Chopbar operators	Old	18	0 (0.00)	8 (44.44)	10 (55.56)
	New	15	0 (0.00)	7 (46.67)	8 (53.33)
Roasted plantain sellers	Old	9	0 (0.00)	7 (77.78)	2 (22.22)
	New	16	0 (0.00)	6 (37.50)	10 (62.50)
Bank	Old	10	10 (100.00)	0 (0.00)	0 (0.00)
	New	10	10 (100.00)	0 (0.00)	0 (0.00)

Percentage (%) in brackets

Total number of "old" Cedi notes examined = 260

Date of issue of "old" Ghana Cedi notes: 4th August, 2003

Table 2: Sources and description of Bank of Ghana "old" and "new" Cedi coins collected between the hours of 7:30am and 9:30 am at each sampling time

Sources of collection	Type of Cedi	Total number examined	Number of Cedi coins examined with specific physical conditions		
			Mint	Fairly clean	Dirty
Fresh fish sellers	Old	5	0 (0.00)	3 (60.00)	2 (40.00)
	New	8	0 (0.00)	4 (50.00)	4 (50.00)
Butchers	Old	6	0 (0.00)	4 (66.67)	2 (33.33)
	New	6	0 (0.00)	6 (100.00)	0 (0.00)
Sachet water sellers	Old	13 8	0 (0.00)	8 (61.53)	5 (38.47)
	New		0 (0.00)	6 (75.00)	2 (25.00)
STC station washroom	Old	7	0 (0.00)	5 (71.43)	2 (28.57)
	New	9	0 (0.00)	8 (88.89)	1 (11.11)
Taxi drivers	Old	7	0 (0.00)	4 (57.14)	3 (42.86)
	New	13	0 (0.00)	8 (61.53)	5 (38.47)
Bank	Old	10	10 (100.00)	0 (0.00)	0 (0.00)
	New	10	10 (100.00)	0 (0.00)	0 (0.00)

Percentage (%) in brackets
Total number of "new" Cedi notes examined = 102
Date of issue of "new" Ghana Cedi notes: 1st July, 2007

Table 3: Bacterial contamination of Bank of Ghana "old" Cedi notes in relation to their sources of collection

Sources of collection of old Ghana Cedi notes	Mean colony forming units per unit surface area (CFU/cm^2)	
	Total bacteria	Coliforms
Porridge sellers	687	357
Fresh fish sellers	1130	372
Sachet water sellers	293	302
Butchers	1006	490
STC station washroom	770	356
Taxi drivers	897	228
Chopbar operators	568	219
Roasted plantain sellers	582	239
	χ^2 = 681.679 df = 7 P= 0.000	df = 7 χ^2 = 186.712 p= 0.000

Table 4: Bacterial contamination of Bank of Ghana "new" Cedi notes in relation to their sources of collection

Sources of collection of new Ghana Cedi notes	Mean colony forming units per unit surface area (CFU/cm^2)	
	Total bacteria	Coliforms
Porridge sellers	585	309
Fresh fish sellers	1046	340
Sachet water sellers	213	295
Butchers	992	398
STC station washroom	687	367
Taxi drivers	845	212
Chop bar operators	563	201
Roasted plantain sellers	511	234
	df = 7 χ^2 = 776.1 p= 0.000	df = 7 χ^2 = 127.2 p= 0.000

Table 5: Bacterial contamination of Bank of Ghana "old" Cedi coins in relation to their sources of collection

Sources of collection of old Ghana Cedi coins	Mean colony forming units per unit surface area (CFU/cm^2)	
	Total bacteria	Coliforms
Fresh fish sellers	563	120
Butchers	546	165
Sachet water sellers	498	139
STC station wash room	523	126
Taxi drivers	487	134
	df = 4 χ^2 = 7.7 p= 0.102	df = 4 χ^2 = 8.8 p= 0.066

Table 6: Bacterial contamination of Bank of Ghana "new" Cedi coins in relation to their sources of collection

Sources of collection of new Ghana Cedi coins	Mean colony forming units per unit surface area (CFU/cm^2)	
	Total bacteria	Coliforms
Fresh fish sellers	480	102
Butchers	512	86
Sachet water sellers	475	94
STC station washroom	493	97
Taxi drivers	487	95
	df = 4 χ^2 = 1.7 p= 0.793	df = 4 χ^2 = 1.4 p = 0.840

Table 7: Fungal contamination of Bank of Ghana "old" Cedi notes in relation to the sources of collection expressed as mean colony forming unit per unit surface area (CFU/cm^2)

Fungal species	Sources of collection: Porridge sellers	Fresh fish sellers	Sachet water sellers	Butchers	STC Station washroom	Taxi Drivers	Chopbar operators	Roasted plantain sellers	Means	
Aspergillus Flavus	65	0	18	5	34	0	7	21	18.8	
Aspergillus fumigates	0	12	0	0	12	0	6	6	4.5	
Aspergillus niger	0	79	37	104	79	74	24	58	56.9	
Aspergillus ochraceus	12	8	0	0	0	0	0	9	3.6	
Cladosporium herbarum	0	0	7	13	5	0	0	18	5.4	LSD(p=0.000): 73.49
Rhizopus sp.	0	0	0	0	0	12	0	0	1.5	
Fusarium sp.	58	24	21	0	9	32	6	0	18.8	
Penicillium sp.	43	12	43	88	13	87	8	0	36.8	
Yeasts	1171	2478	957	2497	1945	1302	1689	1168	1650.9	
Total	1349	2613	1083	2707	2097	1507	1740	1280		
Means	149.9	290.3	120.3	300.8	233.0	167.4	193.3	142.2		

df =56; LSD (p=0.000) : 163.56

Table 8: Fungal contamination of Bank of Ghana "new" Cedi notes in relation to the sources of collection expressed as mean colony forming unit per unit surface area(CFU/cm^2)

Fungal species	Sources of collection: Porridge sellers	Fresh fish sellers	Sachet water sellers	Butchers	STC Station washroom	Taxi drivers	Chopbar operators	Roaste d plantain sellers	Means	
Aspergillus flavus	0	12	4	0	2	6	21	3	6.0	
Aspergillus fumigatus	0	0	34	9	0	1	0	9	6.6	
Aspergillus niger	9	104	16	19	18	23	7	14	26.3	
Aspergillus ochraceus	0	0	0	0	5	0	9	0	1.8	LSD (P0.000): 46.50
Cladosporium herbarum	0	6	9	5	8	0	5	3	4.5	
Rhizopus sp.	5	0	0	4	2	0	7	2	2.5	
Fusarium sp.	4	5	0	3	2	0	7	4	3.1	
Penicillium sp.	6	8	23	12	13	9	12	6	11.1	
Yeasts	819	856	624	934	743	822	914	679	798.9	
Total	843	991	710	986	793	861	982	720		
Means	93.7	110.1	78.9	109.6	88.1	95.7	109.1	80.0		

Df = 56 LSD (p = 0.000) : 43.50

Table 9: Fungal contamination of Bank of Ghana "old" Cedi coins in relation to the sources of collection expressed as mean colony forming unit per unit surface area (CFU/cm^2)

Fungal species	Sources of collection					Means	
	Fresh fish sellers	Butchers	Sachet water sellers	STC station washroom	Taxi drivers		
Aspergillus flavus	263	88	10	27	43	86.2	
Aspergillus niger	242	133	45	26	38	96.8	
Fusarium sp.	0	13	0	38	11	12.4	
Cladosporium herbarum	20	10	5	0	4	7.8	LSD (p=0.000): 33.38
Penicillium sp.	0	177	42	15	36	54.0	
Yeasts	427	313	528	346	297	382.2	
Total	952	734	630	452	429		
Means	158.7	122.3	105.0	75.3	71.5		
	df = 20; LSD (p = 0.000):30.47						

Table 10: Fungal contamination of Bank of Ghana "new" Cedi coins in relation to the sources of collection expressed as mean colony forming unit per unit surface area (CFU/cm^2)

Fungal species	Sources of collection					Means	
	Fresh fish sellers	Butchers	Sachet water sellers	STC station washroom	Taxi drivers		
Aspergillus flavus	46	38	33	24	23	32.8	
Aspergillus niger	96	85	46	83	16	65.2	
Fusarium sp.	0	41	0	0	12	10.6	
Cladosporium herbarum	2	13	22	41	23	20.2	LSD = 22.78
Penicillium sp.	9	2	7	7	3	5.6	
Yeasts	125	105	249	153	95	145.4	
Total	278	284	357	308	172		
Means	46.3	47.3	59.5	51.3	28.7		
	df = 20; LSD (p = 0.000) : 20.80						

Table 11: Bacterial contamination of Bank of Ghana Cedi notes in relation to the period of circulation

Sources of collection of "new" and "old" Ghana Cedi notes	Mean colony forming unit per unit surface area (CFU/cm^2)			
	Total bacteria		Coliforms	
	"Old" Cedi	"New" Cedi	"Old" Cedi	"New" Cedi
Porridge sellers	687	585	357	309
Fresh fish sellers	1130	1046	372	340
Sachet water sellers	293	213	302	295
Butchers	1006	992	490	398
STC station washroom	770	687	356	367
Taxi drivers	897	845	228	212
Chopbar operators	568	563	219	201
Roasted plantain sellers	582	511	239	234
	χ^2 = 13.9 (df = 7; p =0.053		χ^2 = 7.387 (df =7; p = 0.39)	

Table 12: Bacterial contamination of Bank of Ghana Cedi coins in relation to the period of circulation

Sources of collection of "new" and "old" Ghana Cedi coins "Old"	Mean colony forming unit per unit surface area (CFU/cm^2)			
	Total bacteria		Coliforms	
	Cedi	"New" Cedi	"Old" Cedi	"New" Cedi
Fresh fish sellers	563	480	120	102
Butchers	546	512	165	86
Sachet water sellers	498	475	139	94
STC station washroom	523	493	126	97
Taxi drivers	487	487	134	95
	$\chi^2 = 3.4$ (df = 4; p = 0.490)		$\chi^2 = 7.6$ (df = 4; p = 0.108)	

Table 13: Computation of the total surface area of the various Cedi notes and coins sampled

Cash form	Type	Denomination	Computation of total surface area	Total surface area/cm^2
Notes	"Old" Cedis	¢1,000.00	6.95cm x 14.10cm x 2	195.99
		¢2,000.00	7.25cm x 14.70cm x 2	213.15
		¢5,000.00	7.40cm x 15.05cm x 2	222.74
	"New" Cedis	GH¢1.00	6.40cm x 13.30cm x 2	170.24
		GH¢5.00	6.75cm x 14.25cm x 3	192.38
		GH¢10.00	7.10cm x 14.70cm x 4	208.74
		GH¢20.00	7.40cm x 15.00cm x 5	222.00
Coins	"Old" Cedis	¢50.00	2 x(1.37cm)^2 x Π + (2.74cm x Π x 0.20cm)	13.51
		¢100.00	2 x(1.3cm)^2 x Π + (2.6cm x Π x 0.2cm)	12.25
		¢200.00 ¢500.00	2 x (1/2 x 1.1cm x 1.2cm x 7)+ (1.2cm x 0.2cm x 7)	12.60
			2 x(1.2cm)^2 x Π + (2.4cm x Π x 0.3cm)	11.30
	"New" Cedis	GH¢1.00	2 x(1.4cm)^2 x Π + (2.8cm x Π x 0.15cm)	13.63
		Gp50	2 x(1.3cm)^2 x Π + (2.6cm x Π x 0.15cm)	11.84
		Gp20	2 x(1.15cm)^2 x Π + (2.3cm x Π x 0.15cm)	9.39
		Gp10	2 x(1.0cm)^2 x Π + (2.0cm x Π x 0.15cm)	7.23
		Gp5	2 x(0.90cm)^2 x Π + (1.8cm x Π x 0.15cm)	5.94
		Gp1	2 x(0.85cm)^2 x Π + (1.7cm x Π x 0.10cm)	5.07

nature of the sampling method adopted, coins could only be obtained from six out of the nine sources of collection because the change obtained sometimes did not contain any coin. Hence no coin was sampled from porridge sellers, chopbar operators and roasted plantain sellers. Most of the Cedi coins are made of copper, copper alloys (brass, bronze), nickel and steel owing to the high resistance of these metals to corrosion (www.levi-coins.com, 06/01/2011). Though considered in its ionic form as an essential trace element required in most biological processes of prokaryotes and eukaryotes including humans, copper can easily become toxic when in surplus. Thus, copper alloys have been used extensively especially in the developed world as an antimicrobials in hospital settings. Recently however, a study reported the isolation of bacteria that were resistant to the toxic properties exerted by dry metallic copper surfaces (Santo *et al*. 2010). It is therefore not surprising that Cedi coins generally carried lower microbial loads than their counterpart notes as these bacterial isolates obtained might have survived either because they were resistant strains or because of the other non-copper components of the coins. Additionally, banknotes are made of cotton fibres mixed with linen which absorb moisture, whereas coins are made of alloys of copper, brass and bronze which are self-sterilizing and hardly absorb moisture (www.designboom.com 13/02/2009). Thus, bacteria that got onto the banknotes were provided with favourable conditions to grow and multiply faster than on coins. This observation is not different from what has been reported (Barro *et al*., 2006; Beumer, 2007; Prasai *et al*., 2008).

Though it is obvious that cash money in the form of banknotes and coins circulates, it was observed in the current study that the sources of collection could influence the diversity and load of microbes on Cedi notes and coins. Cedi notes collected from fresh fish sellers and butchers were found to be the most contaminated while those obtained from sachet water sellers the least. The likelihood that the environment and unhygienic handling practices are major contributing factors cannot be ignored. In fact, the conditions under which meat and fresh fish are sold on Ghanaian markets might contribute to the heavy loads of microorganisms on Cedi notes and coins. Furthermore sanitation facilities at abattoirs, meat and fresh fish markets are grossly inadequate resulting in the high risk of cross-contamination from simultaneous handling of money and animal products. Other studies reported similar findings about the microbiological status of currency notes and coins (Khin *et al*, 1989; Uneke and Ogbu, 2007). Contamination of currency notes and coins become more hazardous when ready-to-eat food is being sold. For instance, cross-contamination may occur especially when the vendor intermittently handles the food and cash money without any precautions.

Coliforms are lactose fermenting members of the family Enterobacteriaceae, including *E. coli* (Nester *et al*, 2004). The presence of coliforms on Cedi notes and coins was an indication that cash money could be a possible vehicle of transmission of enteric diseases, such as diarrhoea and typhoid (Uneke, 2007). Dey (2003) reported that many banknotes in India were soiled and held together with bits of sticky tapes and were potential killers of visitors not immune to the infections. A study conducted on the Naira, the Nigerian currency, reported that smaller denominations of the Naira notes were often more contaminated than higher denominations as smaller denomination banknotes were routinely and more frequently passed around from one person to another in Nigeria (Umeh *et al*., 2007).

Dirty money is not only confined to developing countries. A number of publications indicate the presence of pathogens on banknotes and coins circulating in the U.S.A., Europe, Australia and other developed nations (Abrams and Waterman, 1972; Micheals, 2002; Pope *et al*., 2002; Xu *et al*., 2005). Additionally, a team of researchers tested banknotes from more than 30 cities in five countries, including the U.S.A, Canada, Brazil, China and Japan, and found

that majority of those banknotes had traces of cocaine and other narcotic substances (American Chemical Society, 2009).

A study conducted in the USA to investigate the potential risks from the transfer of pathogens due to the simultaneous handling of food and money, revealed the presence of harmful bacteria such as *Escherichia coli* and coagulase positive Staphylococcus (Brady and Kelly, 2000). The persistence of coliforms on both "old" and "new" Cedi notes and coins suggests that education of the public on good money handling practices must be intensified.

It was expected that the "new" Cedi notes would carry lower microbial loads than the "old" ones. Unfortunately however, statistical analysis revealed that there were no differences and the results obtained suggest that people's attitude has not changed despite the efforts made by the Bank of Ghana to educate the public on the right way to handle currency notes and coins. The frequency of occurrence of the individual fungal species also varied from one source of collection to the other. A lot of yeast is normally found on the human skin, nose and other body sites. The high loads of yeasts therefore suggest that banknotes and coins might be kept in close contact with our body surfaces such as in bras and socks.

CONCLUSION AND RECOMMENDATIONS

The Ghana Cedi notes and coins were found to carry a variety of fungi, coliforms and other bacteria suggesting that they may serve as medium for transfer of pathogens from person to person. There is therefore the need to intensify the education on handling cash to reduce the potential risks of pathogen transfer between persons. There is even the danger that our currency notes and coins might carry other pathogens such as viruses which investigation was outside the scope of this study. We therefore suggest that viral load of our cash money be investigated. Further studies must also be carried out using molecular biology tools which would better identify the microbes isolated in this study. Additionally, it is likely that the bacteria isolated from coins were copper-resistant; hence, further research should be conducted in order to characterize these strains, which may have health implications. The Central bank could also put plans in place to reduce the use of cash money by introducing debit cards to reduce the rate of transfer of pathogen as money is passed on from hand to hand.

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