British Microbiology Research Journal
5(2): 139-145, 2015, Article no.BMRJ.2015.015
ISSN: 2231-0886

SCIENCEDOMAIN *international*
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Microbial Contamination of Ghanaian Cedi Notes from Traders of the Tamale Central Market, Ghana

P. Luure[1], W. Asare[1*], S. J. Cobbina[1], A. B. Duwiejuah[1] and M. Nkoom[1]

[1]Department of Ecotourism and Environmental Management, Faculty of Renewable Natural Resources, University for Development Studies, Nyankpala, Ghana.

This work was carried out in collaboration between all authors. Authors PL, WA and SJC designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors ABD and MN managed the analyses sample and help the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BMRJ/2015/12551
Editor(s):
(1) Sabina Fijan, University of Maribor, Faculty of Health Sciences, Žitna ulica 15, 2000 Maribor, Slovenia.
Reviewers:
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Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=666&id=8&aid=6150

Original Research Article

Received 5th July 2014
Accepted 26th August 2014
Published 19th September 2014

ABSTRACT

The study was to determine the microbial contamination of Ghanaian cedi notes from traders in the Tamale Central Market, Ghana. A total of ninety (90) currency notes of three lower denominations mainly in circulation (Ghanaian cedi 1, 2 and 5) were collected into sterile paper envelopes. Membrane filtration technique was used to determine total coliform bacteria, *Salmonella* spp and *Escherichia coli*. Microbes isolated from the cedi notes were *Escherichia coli* (19.1%), *Salmonella* species(3.8%), *Bacillus* species (0.4%), *Staphylococcus aureus* (0.0%) and Total coliform (76.6%). The five Ghana Cedi notes had the highest microbial load (746) followed by the two Ghana cedi notes (593) and one Ghana cedi notes (44) recorded the least microbial load. There was also a strong positive correlation (0.97*) between the GH¢5 and GH¢2 notes at 1% significant level which indicate common source of microbial contamination of the cedi notes. Five non-circulated notes denomination were used as control recorded no microbial count. The study revealed that handling of Ghana cedi notes cannot be risk free. It is therefore recommended that individuals should

**Corresponding author: Email: ewilhemina@yahoo.com;*

improve upon their personal health consciousness by washing hands after handling of currency notes.

Keywords: Microbial load; cedi note; membrane filtration; total coliform; buffered peptone water; Tamale Central Market.

1. INTRODUCTION

Money is anything that is generally accepted in payment for goods and services or in the repayment of debts [1]. The word "money" is believed to have originated from a temple of Hera, located on Capitoline, one of Rome's seven hills. In the ancient world Hera was often associated with money. Looking at money in relation to a country as a whole, it is referred to as a currency that is usually in a form of banknote and coin. The introduction of currency dates back between the years of 600 and 650 BC. Paper money or banknotes were first used in China during the Song Dynasty. These banknotes, known as "jiaozi", evolved from promissory notes that had been used since the 7th century and are composed of 25% linen and 75% cotton [2]. Money is used as a medium for exchange for goods and services, settlement of debts and for deferred payments in economic activities [3]. Which serve as a major source of bacteria contamination, the contamination of the cedi currencies could also be from several sources; it could be from the atmosphere, during storage, usage, handling or production [4].

Paper money that is passed from hand to hand is likely to be contaminated with disease-causing microorganisms especially if handled with unclean hands, or kept in dirty surroundings. Paper money, therefore presents a particular risk to public health, since communicable diseases can spread through contact with fomites [5-7]. Money on which pathogenic microorganisms might survive represents an often overlooked reservoir for enteric disease [6]. Paper currency, can be contaminated by droplets during coughing, sneezing, touching with previously contaminated hands or other materials and placement on dirty surface since paper currency is commonly handled by various categories of people during transaction [8]. This therefore makes money one of the dirtiest things humans comes in contact their everyday life. The possibility that currency notes might act as environmental vehicles for the transmission of potential microorganisms was suggested in the 1970s [9]. The use of paper currency for every type of commerce is hard on the currency, with the lower-denomination notes receiving the most handling because they are exchanged frequently [10]. This means that money which may get contaminated during production, storage, after production, and during use are always in circulation [4]. Confirmation of contamination of money by drugs has been detected in the United States and United Kingdom [11,12].

Contamination from the anal region, wounds, droplets during coughing, sneezing, touching with hand placement on dirty surface are potential sources of transfer of microorganisms to currency notes during handling [13,14]. Thus, it becomes obvious that anything that gets on hands get on money. Microorganisms on the skin can be transferred from cashiers, sellers and the general public to notes that they handle [13]. Numerous research on currency in several countries indicated bacteria contamination. A study by Pope et al. [7] and Hosen et al. [15], in Bangladesh revealed coliform contamination of 80% of thirty old two-taka notes, isolated pathogenic or potentially pathogenic organisms from 94% of one-dollar bills. Basavarajappa et al. [16] found 96 out of 100 currencies contaminated with bacteria (*Klebsiella pneumoniae, Escherichia coli, Staphylococcus aureus, Pseudomonas species and Salmonella* Typhi), and Umeh et al. [17] revealed that 89.8% of Nigerian currency notes in circulation within the University of Agriculture, Makurdi Campus has microbial contamination.

The Ghanaian currency, like any other being used in the world is exposed to the potential of bacteria contamination [18]. The Ghanaian currency notes are often dirty, and even mutilated notescan be seen in circulation, although the notes werereleased into circulation in July, 2007 not long ago [19]. The survival of various microorganismson money and their transmission via the hands of food vendors is often overlooked as enteric disease reservoir [6]. Pathogenic microorganisms that may survive on the Ghanaian currency notes may serve as a potential source of enteropathogens causing food poisoning because in Ghana most food vendors serve food with the hands and at the same time handle currencynotes as they sell

[6,20]. Such practices transfer bacteria from currency notes to humans through food [20-22]. The aim of this study therefore, was to determine the level of bacteria contamination of Ghana cedi notes, so as to determine possible source of bacteria contamination of Ghanaian cedi notes, if any.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Tamale Central Market. Tamale is the capital of Northern Region, Ghana. Tamale is the third most populous settlement in Ghana with 537,986 inhabitants according to the 2010 census [23]. The town is located 600 km north of Accra. The metropolis experiences one rainy season from April to September or October with a peak in July and August. The mean annual rainfall is 1100 mm within 95 days of rainfall in the form of tropical showers. Consequently, staple crop farming is highly restricted by the short rain season. The dry season is usually from November to early April. It is influenced by the dry North-Easterly (Harmattan) winds while the rainy season is influenced by the moist South Westerly winds. The mean day temperatures range from 28 (December and mid-April) to 43ºC (March, early April) while mean night temperatures range from 18 (December) to 25ºC (February, March). The mean annual day sunshine is approximately 7.5 hours.

2.2 Sample Collection, Preparation and Analysis

The samples were purposively collected from three types of traders such as tomatoes sellers, fish mongers and meat sellers (butchers).A total of ninety (90) currency notes of three lower denominations mainly in circulation (Ghanaian cedi 1, 2 and 5) were collected into sterile paper envelopes. These samples were made up of 30 one Ghana cedi notes, 30 two Ghana cedi notes and 30 five Ghana cedi notes. Five non-circulated cedi notes each (GH¢1, GH¢2, GH¢5) were obtained from Ghana Commercial bank, Tamale and were used in the investigation as control samples. The samples were collected with gloves into new envelopes, labeled and transported to Water Research Institute laboratory, Tamale for immediate analysis. Isolates determined were *Escherichia coli, Bacillus* species, *Salmonella* species, *Staphylococcus aureus* and total coliform. With the aid of a pair of sterile forceps, each currency note was transferred aseptically into a sterile universal bottle containing 100 ml of sterile buffered peptone water. The bottles were capped and shaken for about two minutes to dislodge the microorganisms from cedi notes into buffered peptone water. The buffered peptone water containing the filtrate served as the test sample whilst the currency notes were removed aseptically from the universal bottle with a sterile forceps, rinsed with distilled water and dried to recover the note.

Total coliform, *Escherichia coli* and *Salmonella* species analysis was done in according with American Public Health Association [24] standard procedures. Membrane filtration technique was used to determine total coliforms, *Escherichia coli* and *Salmonella* speciesin accordance with APHA 9222A, 9260F and 9265. Filtration unit comprising of Erlenmeyer flask, vacuum source and porous support were assembled and with the aid of a flame-sterilized forceps, a sterile membrane filter (0.45µm Millipore) was placed on the porous support. The upper funnel was placed in position and secured with appropriate clamps in a Millipore machine. 100 ml of the buffered peptone water containing the filtrate was aseptically poured into the upper funnel and suction applied to create a vacuum. After the sample was passed through the membrane filter, the filtration unit was taken apart and with the aid of a sterile forceps the membrane filter was placed in the Petri dish containing selective media for various parameters: M-Endo for total coliform, Hi-Chrome agar for *Escherichia coli* and SS agar for *Salmonella species.* Clamps, forceps were usually sterile prior to use for the next sample. All plates were incubated in inverted position at 37 ± 2^0C (total coliform, *Escherichia coli* and *Salmonella* species).

A selective medium known as Mannitol Salt Agar (CM0085) (Chapman medium) was used for the isolation of presumptive pathogenic *Staphylococci*. The medium plate was inoculated with 100 ml of the buffered peptone water containing the filtrate and incubated for 36 hours at 35ºC. *Bacillus* species was analysed in accordance with APHA 9215B by pouring about 10 ml of the buffered peptone water containing the filtrate into a test tube. It was then placed into a water bath at a range of 20-35ºC for 25-30 minutes. After the 30 minutes, 1 ml of the buffered peptone water was aliquoted unto a petri dish. Nutrient agar was poured unto the

sample in the petri dish using pour plate method, and swirled both clockwise and anti-clockwise to ensure a homogeneous mixture and then incubated at 37ºC between 18-22 hours. Colonies were identified using their Morphology and Gram reaction.

2.3 Statistical Analysis

The microbial load of the cedi notes were subjected to Pearson's correlation analysis using SPSS version 16 to determine the relationship that exist between the parameters considered.

3. RESULTS AND DISCUSSION

3.1 Bacteria Contamination of Ghana Cedi Notes in Tamale Central Market

A total of ninety (90) currency notes were analysed for microbial contamination. One thousand, three hundred and eighty-three (1383) microbes were isolated from the ninety (90) samples (cedi notes) analysed representing 99.9% contamination (Table 1). Microbial loadof the notes were *Escherichia coli* (19.1%), *Salmonella* species(3.8%), *Bacillus* species(0.4%), *Staphylococcus aureus* (0.0%) and total coliform (76.6%) (Table 1). The study observed 99.9% microbial loadof Ghana cedi notes in circulation. Comparatively, other researchers have detected contamination levels of 90% [25], 100% [18], 80%[15], 96% [14] and 94%[7]. The microbial loadof the cedi notes indicates that handling money is not risk free. Total coliform was the highest isolate (76.6%) while *Staphylococcus aureus* was the least isolate (0.0%) with no count on any of the Ghana cedi notes (Table 2). The high total coliform contamination of cedi notes might have come from sources such as soil, water, human and animal waste. It is a usual phenomenon for money to periodically fall out of the hands of its users, get in contact with water or sweat and also get contaminated with coliforms from dirty hands or where meat are processed (abattoir).

According to Healthvermont [26] the presence of coliform bacteria on the Ghana cedi notes reveals a high risk of getting infected with coliform related diseases such as diarrhoea and giardiasis. The one Ghana cedi notes were contaminated with 9.1% of *Escherichia coli,* 50.0% of *Salmonella* species*,* 0.0% of *Bacillus* species, 0.0% of *Staphylococcus aureus* and 40.9% of Total coliform. The two Ghana cedi notes had 27.0% of *Escherichia coli,* 5.2% of *Salmonella* species*,* 0.0% of *Bacillus* species*,* 0.0% of *Staphylococcus aureus* and 67.8% of Total coliform. Also, the five Ghana cedi notes had 13.4% of *Escherichia coli,* 0.0% of *Salmonella* species*,* 0.8% of *Bacillus* species, 0.0% of *Staphylococcus aureus,* and 85.8% of Total coliform (Table 2). There was a strong positive correlation (0.97*) between the GH¢5 and GH¢2 notes at 1% significant level indicating their source of contamination is common (Table 3). The strong positive correlation shows that, the microbial load of these cedi notes might have originated from the same source of pollution. This could either be from where the traders keep their money (plastic and metal containers) or from the products they sell (fish and meat).

Escherichia coli recorded a percentage contamination of 19.1% which was the second highest count. It is a gram-negative bacterium which is mostly found in the intestinal tracts of warm blooded mammals. *Escherichia coli* is a strain of total coliform and this relation could explain the reason why it is the second highest contaminant. This finding contradicts similar research conducted in Kumasi by Feglo and Nkansah [18] revealed that *Escherichia coli* had the least contamination of 1.78%. A potential source of this could be from the abattoir (meat sellers) since the traders could pick contaminants from the intestines and excreta. Several types of *Escherichia coli* species also exist as normal flora in the human gut and have many beneficial functions such as the production of vitamin K2. An *Escherichia coli* serotype 0157:H7 can cause health implications such as food poisoning, severe anemia or even kidney failure [27].

Salmonella species recorded a percentage contamination of 3.8% making it the third highest isolate. This type of bacteria is mostly found in the intestinal tracts of vertebrates [28]. A similar study conducted in Nigeria revealed a 40.9% contamination of *Salmonella* species [17]. The possible source of its presence in the cedi notes could be from the fishmongers and the butchers within the market. This therefore makes the handling of the cedi notes not risk free since S*almonella* species can result in health implications such as typhoid fever, diarrhoea and food borne illness if there is exposure to it. This level of contamination could also be as a result of the close relationship between the genus of *Escherichia* and *Salmonell*a and that the environment probably favours *Escherichia coli* more for growth.

Bacillus species are rod-shaped, gram-positive bacteria that are widely found in soil and water. During this study, a 0.4% contamination was recorded making it the fourth highest isolate. Comparing the results of this study to a research conducted Feglo and Nkansah [18] and Tagoe et al. [29] the percentage of 41.07% and 23.4% contamination were obtained respectively. Some members of this genus (eg. *Bacillus anthracis)* can cause serious infectious diseases such as anthrax disease, severe wound infections and also often fatal if spores are inhaled. *Bacillus* species being gram-positive means that, they are able to survive under harsh weather conditions and are mostly found on the human skin. They form spores under unfavourable conditions which are resistant to heat, sunlight and extremely high temperatures. The contamination of *Bacillus* species in this study was low probably because the currency wasn't much of a suitable environment for its growth so spores were formed, awaiting favourable conditions. These spores of *Bacillus* species when transferred, can find suitable environment in places such as water, soil and on the human skin.

Staphylococcus aureus recorded no count making it the least isolate. It is for this reason that, the total contamination in percentage was 99.9%. In contrary, research conducted by Feglo and Nkansah [18] in Kumasi and Tagoe et al. [29] in Cape Coast revealed 7.14% and 8.4% contamination respectively. This difference could be attributed to unfavourable weather conditions. Probably, *Staphylococcus aureus* could be in higher contamination in the south compared to the north as result of temperature differences. It is found on human skin and in the nose and does not cause infection unless it gets into the skin probably through a cut which in that case, causes diseases such as bloodstream infections and pneumonia not forgetting food borne illness when it comes into contact with food [30]. It is also able to form very high resistive heat temperatures especially when it comes into contact with food.

In 2007, Bank of Ghana noted the several unhygienic conditions (butchers with bloody fingers, the street-food vendor with oily-wetly fingers and fish mongers with oily fingers) that contaminate the Ghanaian currency notes without any hygienic intervention [19]. Folding or crumpling of banknotes creates pouches or crevices which could harbour dust and microorganisms; some of which may grow or remain in a quiescent stage for long periods until they find suitable environment to grow and multiply [19]. The habit of keeping money in bags, pockets, handkerchiefs, brassieres and wallets have also been observed among Ghanaians which may be of large contribution to the high microbial load. This study also contradicts the results of previous works that reported that microbial contamination on lower denominations is higher than on higher denominations [4,6,7,8,10,17,18,31]. *Salmonella* spp*, Escherichia coli* and Total coliform concentration were very high in GH¢2 and GH¢5 notes when compared to that of GH¢1 notes. However, this difference can be related to the type of microbes being studied and the environmental conditions.

Table 1. Microbial load of Ghana cedi notes

Microbial isolates (cfu)	GH¢ 1 (count)	GH¢ 2 (count)	GH¢ 5 (count)	Percentage (%)
Escherichia coli	4	160	100	19.1
Salmonella species	22	31	0	3.8
Bacillus species	0	0	6	0.4
Staphylococcus aureus	0	0	0	0.0
Total coliform	18	402	640	76.6
TOTAL	44	593	746	99.9

Table 2. Microbial load in percentage

Microbial isolates (cfu)	GH¢ 1 (%)	GH¢ 2 (%)	GH¢ 5 (%)
Escherichia coli	9.1	27.0	13.4
Salmonella species	50	5.2	0.0
Bacillus species	0.0	0.0	0.8
Staphylococcus aureus	0.0	0.0	0.0
Total Coliform	40.9	67.8	85.8
Total	100	1000	100

Table 3. Correlation matrix of microbial load of cedi notes

Cedi Notes	GH¢ 1	GH¢ 2	GH¢ 5
GH¢ 1	1	0.47	0.46
GH¢ 2		1	0.97
GH¢ 5			1

**Correlation is significant at the 0.01 level*

4. CONCLUSION

The study revealed Ghana cedi notes circulated by traders in Tamale central market are contaminated with *Escherichia coli*, *Salmonella* species, *Bacillus* species and Total coliform. This therefore confirms the statement that, Ghanaian currency notes in circulation under a variety of personal and environmental conditions are indeed contaminated with microbes which can be harmful to human. Based on the findings of this study public awareness of the fact that currency notes could be a source of infection and could be dangerous to human health should be created. Individuals should improve upon their personal health consciousness by washing hands after handling of currency notes. Bank of Ghana should educate the public and enforce rules on proper ways of handling money.

COMPETING INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=666&id=8&aid=6150