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A Study of Bacterial Contamination on Libyan Paper Banknotes in Circulation

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Abstract

Paper currency is one of the potential vectors to transmit diseases, since banknotes continuously pass through different hands, as a medium of exchange, which increases the possibility of transferring pathogenic microorganisms and thus cross contamination. This study was carried out on one hundred and ninety-eight paper currency notes that were collected randomly in the city of Tripoli, Libya, from different communities namely, petrol and gas stations, supermarkets, mini markets, cafeterias and fast food restaurants, etc. The samples consist of four pieces, each of currency (Dirham) denominations (250, 500, 1.000 and 5.000 notes). Conventional and current microbiological techniques were used in order to isolate and identify the species of microorganisms that resulted in the following percentages: *Enterobacter agglomerans* 19%, *Pseudomonas* spp. 16%, *S. aureus*, *Enterobacter cloacae* 11%, *Klebsiella pneumonia* 11% and *E. coli* 10%. These results indicate that Libyan banknotes are commonly contaminated with pathogenic bacteria, which have the possibility of spreading human diseases. Higher denomination currency showed lower contamination. Consequently, great care should be taken during the handling of money for the safety of human health.

1. Introduction

Environmental conditions plays a significant role in transmission of microbes to humans and many environmental materials serve as vehicles [1]. Human pathogens can be transferred directly through physical contact, or indirectly by many other environmental materials such as: air, water, food or other inanimate objects, which can lead to widespread infection and disease in humans [2, 3, 4]. That can cause serious problems for health care personnel and patients with compromised immune systems [5]. Paper banknotes play an important role in the life of human beings, since they are widely used and exchanged for goods or any other services required and are handled by several people societies during transaction. Generally, paper money represents a particular risk to public health as it carries potential pathogenic bacteria [6]. Many people do not care how clean or dirty their hands are when they are handling or counting money. The contaminated currency notes get in circulation and therefore spread contaminated microbes to others hand and therefore transmitting the pathogens by this process [7].

These means of transmissions are of significance in many populations health, especially in developing countries. The types of infections, however, reflect the general signs of local hygiene and environmental sanitation level [1, 8]. Previous studies have demonstrated that, bacteria are among the most common microbial pathogens found in currency notes, especially those within the families of *Enterobacteriaceae* [9], *Bacillus* species, and *Staphylococcus* species. [10]. Furthermore, other studies have shown that bacteria in notes are *Acinetobacter* species, *Pseudomonas* species, and *Escherichia* species. Moreover, these bacteria can survive for months on dry surfaces [11]. The level of contamination probably depends on how long the note has been in circulation; the general hygiene level of the population, season, environmental conditions and the type of material the money is made of [2, 5]. Therefore, this study aims to determine the extent of the presence of bacterial contamination associated with Libyan paper banknotes in circulation, collected from different categories of people in Tripoli, the capital of Libya.

2. Materials and Methods

2.1. Collection of Samples

A total of 198 samples of Libyan paper banknotes (250, 500, 1.000 and 5.000 Dirham) were collected from various business locations in Tripoli, including, cafeterias, supermarkets, minimarkets, fast food restaurants, petrol and gas stations, etc.

Geographic coordinates: the city of Tripoli is located in the northwestern part of Libya at 32°62'54"N and 13°22'75"E, which is home to 1.7 million individuals and approximately 27.41% of the Libyan population [12, 13].

The respective persons were requested to place the samples directly into sterile polythene bags. The samples were then sealed and transported immediately to microbiology laboratory for microbiological analysis.

2.2. Isolation and Identification of Bacteria

Isolation of bacteria from the notes was performed using standard techniques described previously [14, 15]. Briefly, sterilized wet (1% peptone water) swab were used and rubbed on both sides of the notes. Each paper banknote was placed in 100 ml of nutrient broth (Oxoid) and incubated aerobically at 37°C for 18 hours to enrich the bacteria prior to plating it onto selective agar. Using a sterile microbiological loop, the inoculums were streaked onto Blood agar (Oxoid), Eosin Methylene Blue Agar (Oxoid), MacConkey Agar (Oxoid) Manitol salt agar (Oxoid), Baird-Parker Agar (Oxoid), Salmonella Shigella agar (Oxoid), XLD agar (Oxoid). The plates were incubated at 35-37°C for 24-48 hours. Suspected colonies were isolated and identified biochemically using standard microbiological procedures [14, 15], that include Gram stain. Also a coagulase test was conducted to know coagulase positive for *S. aureus*, catalase

test, oxidase test, hemolysis, sugar fermentation, and other biochemical tests using API 20E (bioMerieux, France).

3. Results and Discussion

In the current study, the identification and enumeration of various types of pathogenic microorganisms that were obtained from the Libyan banknotes were contaminated with some strains of the pathogens bacteria. These results were compatible with previous researchers from other countries which elucidated that currency banknotes are usually contaminated by pathogenic microorganisms [2, 3, 5]. One hundred and ninety-six isolates obtained from the collected samples representing selected eight different types of bacterial species. The results showed that the active participation of these eight species in descending order of percentage as shown in (Table 1), *Enterobacter agglomerans* was the most frequently encountered bacteria recovered from paper banknotes followed by *Pseudomonas* spp., *S. aureus*, *Enterobacter cloacae*, *Klebsiella pneumonia*, *E. coli*, *Serratia ficaria*, *Enterobacter sakazakii*, *Acinetobacter* spp. and *Kluyvera* spp.

Table 1. Potentially pathogenic bacteria of Libyan banknotes.

Potential pathogens	Percentage (%)
<i>Enterobacter agglomerans</i>	38 (19%)
<i>Pseudomonas</i> spp.	32 (16%)
<i>Staphylococcus aureus</i>	22 (11%)
<i>Enterobacter cloacae</i>	22 (11%)
<i>Klebsiella pneumonia</i>	21 (11%)
<i>Escherichia coli</i>	20 (10%)
<i>Serratia ficaria</i>	14 (7%)
<i>Enterobacter sakazakii</i>	10 (5%)
<i>Acinetobacter</i> spp.	10 (5%)
<i>Kluyvera</i> spp.	7 (4%)

There was a higher frequency of circulation for the 250 Dirham notes when compared with the other currency denominations sampled. The total percentage of the microbial isolate from the notes were shown (Fig. 1) as the following, with *Enterobacter agglomerans* having the highest bacterial percentage occurrence of 50%. The next highest pathogen found in the sample collected was *Staphylococcus aureus*, contributing to 24% of the population. Other pathogenic species such as *Enterobacter cloacae*, *Serratia ficaria* had 10%. This is followed by the *Pseudomonas* spp. (10%), *Enterobacter sakazakii* and *Klebsiella pneumonia* (8%). *Acinetobacter* spp. was the least encountered with 4% while *Escherichia coli* and *Kluyvera* spp. was not found in this currency. This study revealed prevalence of bacterial contamination in the currency notes indicating that handling money can introduce certain risks. Therefore, as pathogens on currency notes survive, they may multiply [5]. Also, they may cause food borne illnesses and that represents an often overlooked enteric disease reservoir [16, 3]. This is of concern, due to the fact that currency notes could serve as a vehicle for transmission of diseases.

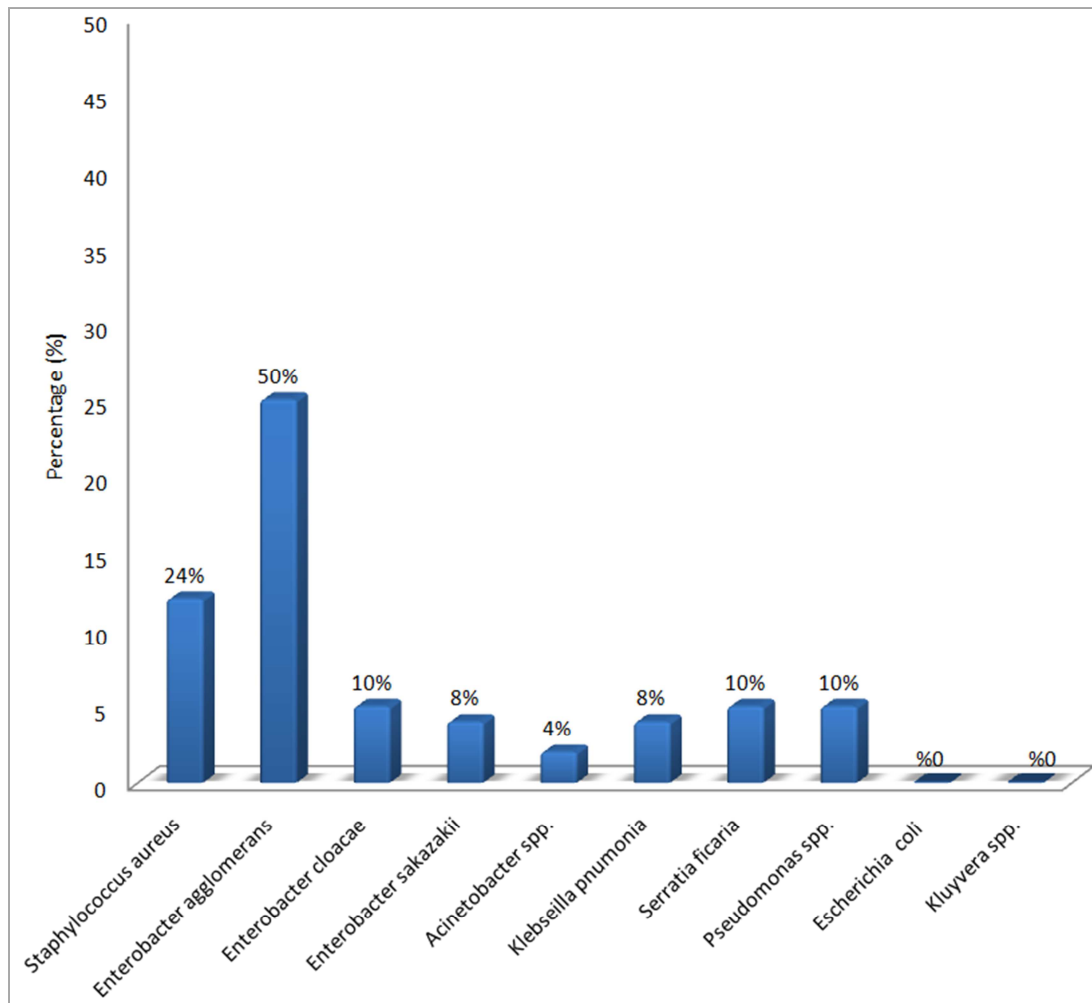


Figure 1. Percentage occurrence of microorganisms incidence per denomination of Libyan banknotes (250 D).

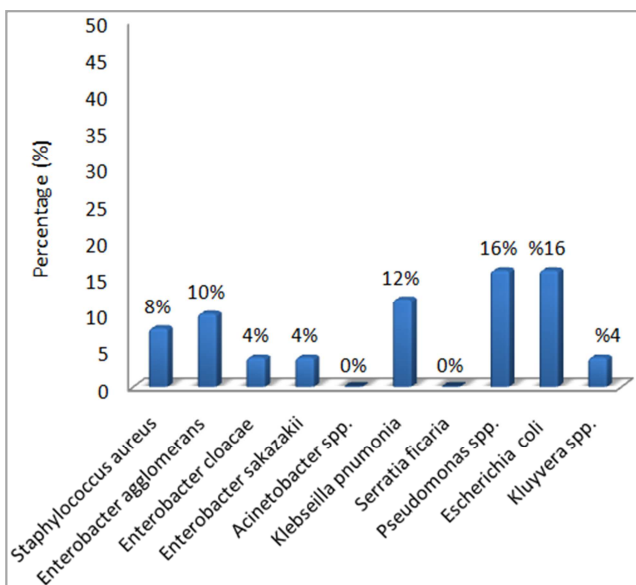


Figure 2. Percentage occurrence of microorganisms incidence per denomination of Libyan banknotes (500 D).

There were 8 specie isolates of bacteria found in the 500 Dirham notes; of which 16% were *E. coli* and *Pseudomonas* spp. (Fig. 2). It was followed by *Klebsiella pneumoniae* (12%), *Enterobacter agglomerans* (10%). *Staphylococcus aureus* contributed 8%, to the total isolates present on these notes (500 Dirham). Isolates *Enterobacter sakazakii*, *Enterobacter cloacae* and *Kluyvera* spp. were found to be 4% of total population. Remarkably, no members of *Serratia ficaria* and *Acinetobacter* spp. were found.

In general, the money collected in this study was found to be contaminated with potentially pathogenic bacteria, including several strains associated with the intestines, also they may cause oral and dental healthcare-associated infections, such as *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Enterobacter* [17, 18]. Whereas, some of the bacteria isolates were present in the environment or as normal flora in humans. High bacteria loads were associated with the 250 Dirham notes. There is a high possibility of the reason being, its domination of most daily cash transactions. The isolated bacteria obtained from this study are compatible with many other studies [4, 19, 20, 21]. Suggesting cross-contamination is a common phenomenon.

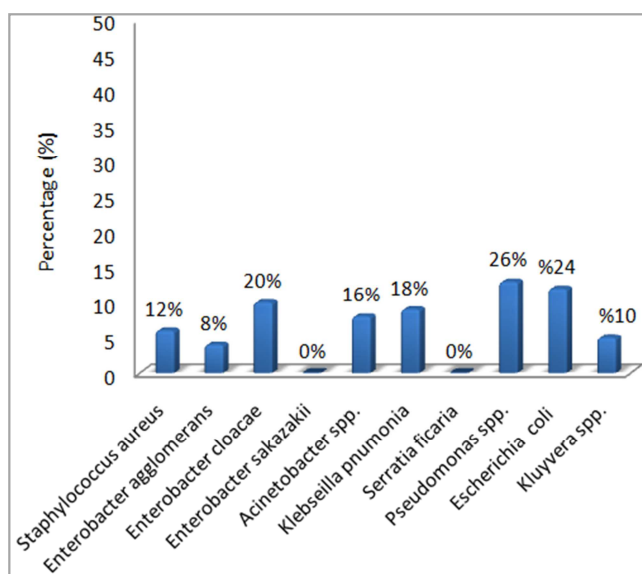


Figure 3. Percentage occurrence of microorganisms incidence per denomination of Libyan banknotes (1000 D).

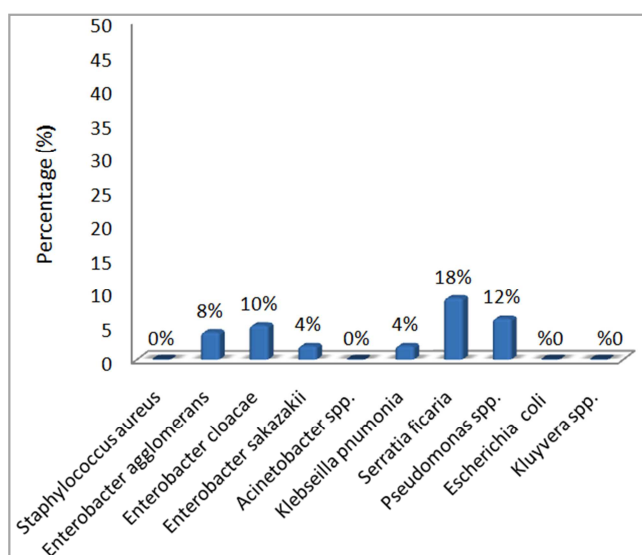


Figure 4. Percentage occurrence of microorganisms incidence per denomination of Libyan banknotes (5000 D).

The highest bacteria found in the banknotes samples (1.000 D) collected, was *Pseudomonas* spp. contributing 26% and *E. coli* 24% (Fig. 3). Other pathogenic species such as *Enterobacter cloacae* (20%), *Klebsiella pneumonia* (18%), *Staphylococcus aureus* (12%), *Acinetobacter* spp. (16%). Also *Enterobacter agglomerans* were present with 8%. No members of *Enterobacter sakazakii*, *Kluyvera* spp. and *Serratia ficaria* were found. Among the different bacterial isolates, such as *S. aureus*. Which is a major pathogen for humans, for it can cross contaminate foods and cause food poisoning. It has been recognized for cross implication in various types of infections; pneumonia, skin infection impetigo, endocarditis, septic arthritis, gastroenteritis localized collection of pus, known as an abscess [9, 22]. *E. coli* are common enteric microorganisms that are possible pathogens which may cause respiratory illness, diarrhea,

urinary tract infections, bloodstream infections and other illnesses [23, 24]. Another pathogenic bacteria, *Klebsiella pneumonia*, is a virulent organism, associated with a wide range of infections, such as pyelonephritis, osteomyelitis, urinary tract and wound infections, especially in immuno-compromised individuals [25, 26]. Similarly, *Acinetobacter* spp., have emerged as infectious agents of nosocomial infections, including bacteremia and urinary tract infection [27]. The isolated bacteria (Fig. 4) resulted as: *Serratia ficaria* (18%), *Enterobacter cloacae* (10%), *Enterobacter agglomerans* (8%), *Klebsiella pneumonia* and *Enterobacter sakazakii* (4%). Compared to the other notes that were experimented on, over all, the percentages in the 5.000 Dirham notes turned out to be considerably low, showing that the contamination and incidence of pathogenic organisms were less than that of the 250, 500 and 1.000 Dirham notes.

The presence of these pathogenic bacteria reveals that the majority of people are exposed to contaminated currency notes. Keeping money in dirty places and as a habit, wetting fingers with saliva while counting currency notes suggests that humans are the major source of microorganisms on currency. As damaged or soiled notes are contaminated, they are particularly dangerous to health. Additionally, unwashed fingers contained many microorganisms, of which could be transient or resident [28]. These practices, including indiscriminate coughing, sneezing and defecation with indecent handling of currency notes were the most common sources of contamination [4, 9]. Furthermore, the materials of which the currency was manufactured are probably a factor that affects the survival of microorganisms on the banknotes [3].

Our study indicates that Libyan banknotes could serve as a vehicle to the transmission of potentially harmful bacteria. Accordingly, such a situation should be a matter of concern for public health authorities. Reducing or eliminating the amount of microbial sources before they contaminate banknotes goes a long way toward simplifying treatment and reducing costs associated with a contaminated supply. Regular withdrawal of damaged notes by the national authorities (central banks) and the services on credit cards which could reduce the transmission of bacteria. In addition, it is recommended that individuals are to improve upon their personal health by washing hands with soap and water immediately after the handling of banknotes. Heat-sterilization of money or disinfection of the currencies in banks with ultraviolet light radiation, are recommended for reducing the contamination [3] and issuing them with expiry dates [29]. Many studies used antibiotics to eliminate pathogenic bacteria in currency, however some of these bacteria could resist common antibiotics and therefore they represent a risk to the public health in the community [30, 31].

Ionizing radiation is an effective technology for sterilization of disposable medical equipment and food, therefore it could be utilized to eliminate pathogenic bacteria from contaminated notes. The mode of action of this method relies on breaking of double strand DNA, which become non-

repairable [32]. It is strongly recommended that other studies on this subject are required to be performed on other country areas in order to enhance pathogenic bacteria cross-contamination between Libyan society individuals.

4. Conclusion

As a result of carried out work – Libyan paper banknotes in circulation were found to be commonly contaminated with various types of human pathogenic and non-pathogenic bacteria, which may spread diseases to immune compromised individuals in hospitals and in the community. Therefore, in order to reduce the level of contamination, public awareness campaigns on money handling practices should be done. It is very important that banknotes are handled with proper hygiene specially for those who simultaneously handle money and food.

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