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Evaluating the Level of Bacterial Contamination on Libyan Banknotes and Coins in Circulation City

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ABSTRACT

Background: Since money is a means of trade that passes through several hands and increases the possibility of transmitting harmful microbes and consequent cross-contamination, it is one of the potential vectors for the transmission of illness. In addition to their denominational values, currency can harbor infections and serve as a medium for the spread of illness.

Aim of the study: The aim of this research was to examine and ascertain the level of bacterial contamination present in Libyan coins and banknotes that are in circulation in the markets of Benghazi, Libya.

Methods: The study's currency notes were evaluated using microscopic, biochemical imaging, and microbiological culture methods.

Results: The study's findings revealed that microbiological contaminations increased with decreasing money denominations, and that frequency % decreased with increasing isolations. Of the 10 centers that were chosen, cafes were the main source of tainted cash. In all currencies under examination, the most prevalent percentage of microorganisms are *Shigella spp.* and *Serratia spp*. 45 (29.0%) and *Staphylococcus aureus* 30 (19.4%). *Pseudomonas spp*. 20 (12.9%), *Escherichia, Klebsiella, and Enterobacter spp.* 5 (3.2%) are also often found.

Conclusions: The study's findings demonstrated that currency notes may serve as a conduit for the spread of microbes that result in infectious illnesses, posing a risk to the public's health for both individuals and the community.

Keywords: Currency; Bacterial isolates; Antimicrobial; Benghazi; Libya.

1. Introduction

Since paper money is extensively utilised, exchanged for commodities and other necessities, and handled by several individuals' societies during transactions, paper money plays a significant part in human life. Paper money, in general, poses a special risk to public health since it may contain harmful microorganisms [1]. When touching or counting money, a lot of individuals don't care how clean or dirty their hands are. Because the tainted banknotes are in circulation, infected microorganisms are transferred to other people's hands, which in turn spread the diseases [2].

It is often known that germs may be found practically wherever in our surroundings includes money, the most often used item in daily life. Since these coins and banknotes are necessary for the purchase of goods and services anywhere in the globe, it is determined that the contaminated money poses a risk to public health as the infection spreads. When the tainted banknotes are in use and get on other people's hands, they spread germs to other people. Paper money that has been placed on unclean surfaces or polluted by droplets from coughing or sneezing might taint it [3].

The fact that purchasing everyday goods transfers microorganisms from one place to another means that these papers, which are typically passed from hand to hand, are more likely to become contaminated with potentially pathogenic bacteria through various handling methods [4].

Additionally, handling money in an unhygienic environment raises the risk of spreading harmful microorganisms across the community or civilization [5]. The germs present on banknotes have the potential to cause a broad range

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of illnesses; between 1980 and 1992, there was an estimated 58% rise in the death rate from bacterial infectious diseases. However, research conducted throughout the globe has revealed that there is a significant amount of bacterial contamination on banknotes that are in use [6]. This included members of the family *Enterobacteriaceae, Mycobacterium tuberculosis, Vibrio cholera* and *Bacillus spp.* [7]. *Staphylococcus aureus* and other *Bacillus species* have been shown to be frequent pollutants found in germs recovered from paper money notes [8]. Banknote money may be involved because infectious illnesses can spread through touch with hands, clothing, and other objects. Antimicrobial resistance has been rising over time [9].

Thus, the purpose of this study is to ascertain the degree of bacterial contamination linked to Libyan banknotes that are in use. The data for this study was gathered from various banks and coins that are in use in Benghazi city's market places. The study's objective is to evaluate the amount of bacteria present in Libyan coins and banknotes that are traded in the city of Benghazi's marketplaces.

2. Materials and Methods

2.1. Collection of Samples:

A total of one hundred samples of Libyan banknotes and coins, including the 250,500, Dirham, and the 1, 5, and 10 Dinar, were gathered from different commercial establishments in Benghazi city, such as vegetable and food stores, bakeries, butcher shops, and cafes. Applying an adapted method from Igumbor [10], Samples from each banknote (250,500, Dirham, 1, 5, and 10 dinars) were taken using gloves and put in a sterile plastic container. The banknotes were aseptically put in sterile individual universal bottles with 10 ml of 1% peptone water broth when they got to the lab, and the bottle was shaken a lot for two minutes. They were soaked and vortexed for 30 minutes, and then they were removed using sterile forceps. The resultant Peptone water solution was used as a test sample and incubated at 37°C for a whole day.

2.2. Isolation and Identification of Bacteria

The notes' bacteria were isolated using the previously mentioned conventional techniques [11], [12]. Every banknote is aseptically placed into a separate universal bottle with 10 milliliters of sterile buffer peptone water, and the bottle is shaken rapidly for a duration of two minutes. After the money is taken out, the Peptone water solution is used as a test sample. It is then aerobically incubated for 24 hours at 37°C to enrich the bacteria before being plated onto selective agar.

The microbiological loop was kept sterile and used to streak the inoculums onto MacConkey and Blood agar. For twenty-four hours, the plates were incubated aerobically at 37°C. Standard microbiological techniques were used to isolate and biochemically identify suspected colonies [11], [12], that include the Gram stain. In addition, the Triple Sugar Iron (TSI) test is used for additional biochemical tests such as the oxidase and catalase tests.

2.3. Antibiotic Susceptibility Testing

Using previously published standard protocols, the preparation, standardization of antibiotic discs, and analysis of the resistance pattern for bacterial isolation from notes were completed [13].

2.3.1. Preparation of filter paper discs and antibiotic stock solution

Using a standard office hole punching machine, holes of around 6 mm in diameter were punched onto Whatman filter paper, which was subsequently hot-air oven sterilized for 30 minutes at 70 C.

The creation of antibiotic stock solutions, which include dissolving a known weight of antibiotic powder in sterile distilled water and storing the mixture in the refrigerator for later use, was the next stage in the investigation.

The next stage involved impregnating the discs, which involved using a mechanical pipette to fill each disc with antibiotic solutions. 20µl or 0.02 ml of liquids may be absorbed by a 6 mm diameter paper disc. Antibiotic solution concentrations were given in units of µg/µl.

2.3.2. Antibiotic sensitivity test

Using the agar diffusion technique on Mueller-Hinton agar (a modified version of the Kirby-Bauer NCCLS disc diffusion technique), the antimicrobial sensitivity test was conducted to ascertain the sensitivity profiles of the isolated bacteria to certain antibiotic discs. There were seven antibiotic discs utilised.

The most often used discs in Libyan hospitals for the treatment of bacterial infections are Ciprofloxacin (20g), Amikacin (20g), Gentamicin (20g), Amoxicillin (20g), Erythromycin (20g), Amoxicillin/Clavulanic (20g), and Ampicillin/Cloxacillin (20g).

2.4. Statistical Analysis

After entering the raw data from the microbiological study into a Microsoft Excel 2007 spreadsheet, the counts were converted to log10 for a normal distribution.

Subsequently, the data were exported into the SPSS-IBM version 21.0 programme, where they underwent descriptive statistical analysis and were shown as tables.

3. Results

Out of the 100 samples examined, 155 bacterial isolates were found. 100% of the 100 samples that were examined had different types of bacteria present in them. This study's findings about bacterial contamination are as follows: Of all the bacteria found, seventy-nine percent are classified as gram-positive, while the remaining thirty percent are classified as gram-negative (Table 1 and Figures 1, 2).

Table 1. The percentage of bacteria, both Gram-positive and Gram-negative, those were isolated from currencies in Libya

Gram stain	Frequency	Percent	Valid Percent
Gram Negative	70	70.0	70.0
Gram Positive	30	30.0	30.0
Total	100	100.0	100.0

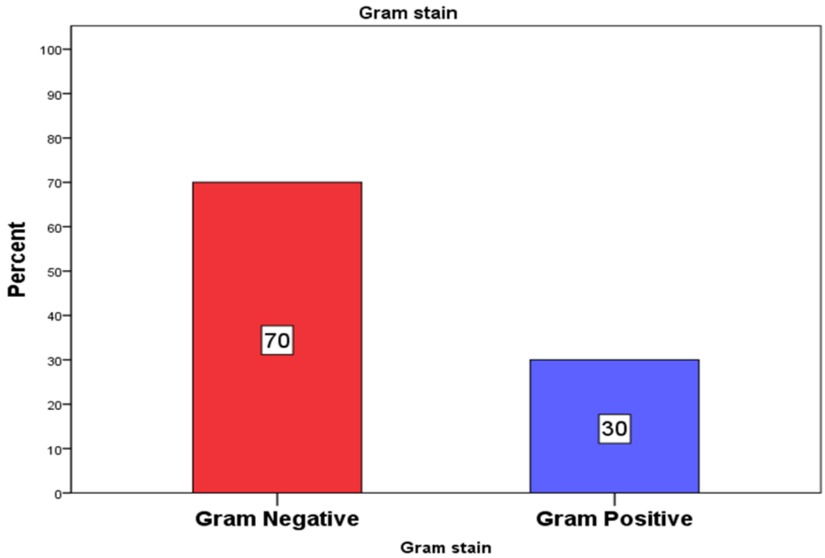

Figure 1. The percentage of bacteria, both Gram-positive and Gram-negative, those were isolated from currencies in Libya

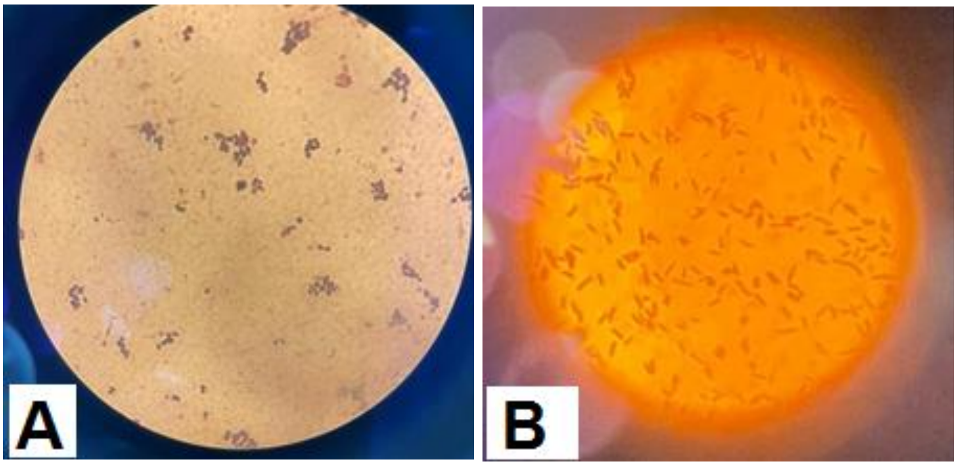

Figure 2. (A) Gram positive bacteria, and (B) Gram negative bacteria

According to Table 2 and Figure 3, the most frequent isolates were *Shigella spp.* and *Serratia spp.* 45 (29.0%) and *Staphylococcus aureus* 30 (19.4%). *Pseudomonas spp.* 20 (12.9%), *Escherichia*, *Klebsiella*, and *Enterobacter spp*. 5 (3.2%) were the next most common isolates.

Table 2. Distribution of bacterial isolates according to sources of currency notes

Bacteria Specie	Frequency	(N%)	Cumulative Percent
Pseudomonas spss	20	12.9	12.9
Staphylococcus aureus	30	19.35	32.3
Shigella	45	29.03	61.3

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Serratia	45	29.03	90.3
Escherichia	5	3.226	93.5
Klebsiella	5	3.226	96.8
Enterobacter	5	3.226	100.0
Total	155	100.0	

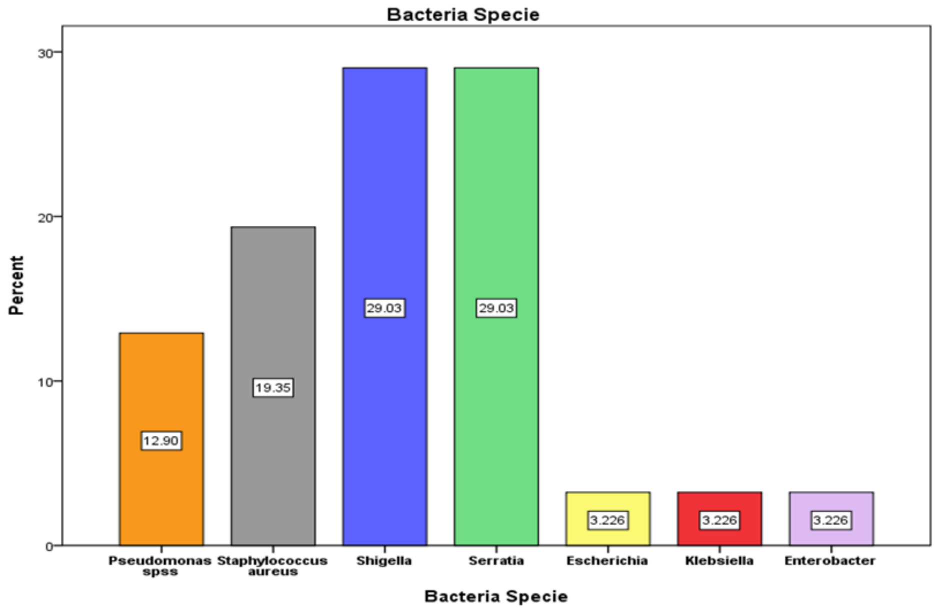

Figure 3. Percentage of bacterial isolates according to sources of currency notes

The distribution of bacteria that were isolated from five distinct sources is displayed in Table 3 and Figure 4. Cafes contained 35 (22.6%), 34 (21.9%), 31 (20.0%) in the food store, 28 (18.1%) in the bakery, and 27 (17.4) in the vegetable store out of the 155 bacteria that were recovered. The most prevalent bacteria in vegetable stores (N=7) are *Shigella spp., Serratia spp.*, and *Pseudomonas spp.;* in cafes (N=7), *Shigella spp., Serratia spp.*, and *Staphylococcus aureus* are the most prevalent bacteria; and in bakeries (N=9), *Staphylococcus aureus* is the most prevalent bacteria. The most common types in Foodstuff Store (N=9) are *Shigella spp. and Serratia spp.*, followed by Butcher (N=14).

Table 3. Distribution of bacterial isolates according to sources of currency notes

Bacteria Specie	**Vegetable Store**	**Cafes**	**Bakeries**	**Foodstuff Store**	**Butcher**	**Total**
Pseudomonas spss	7	2	3	3	5	
Staphylococcus aureus	6	7	9	7	1	

Shigella spss	7	7	8	9	14	
Serratia spss	7	7	8	9	14	
Escherichia spss	0	4	0	1	0	
Klebsiella spss	0	4	0	1	0	
Enterobacter spss	0	4	0	1	0	
Total	27	35	28	31	34	155
N%	17.42%	22.58%	18.06%	20.0%	21.94%	% 100

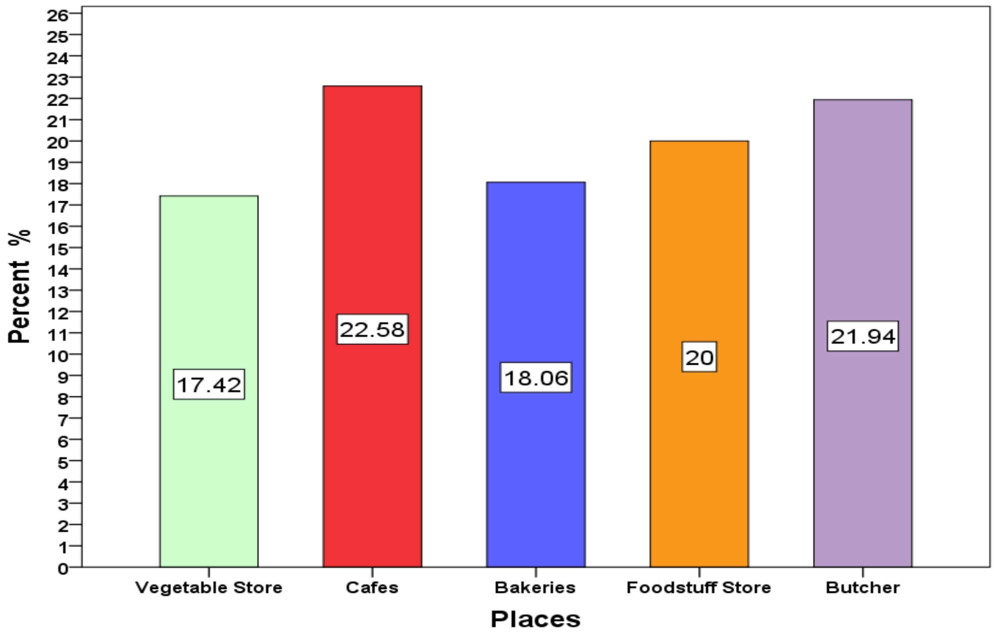

Figure 4. Percentage of bacterial isolates according to sources of currency notes

The frequency of bacterial isolates on various denominations of Libyan banknotes is displayed in Table 4 and Figure 5. 42 (27.1%), 36 (23.3%), 35 (22.58%), 25 (16.13%), and 17 (10.97) of the 155 isolates came from 500, 1.000, 250, Five, and Ten dinar notes, respectively ($p < 0.05$).

Table 4. Distribution of bacterial isolates based on the currency notes denomination

Isolated bacteria	250 Dirham		500 Dirham		One Dinar		Five Dinar		Ten Dinar		Total	Total
	(N)	(N%)	(N)	(N%)	(N)	(N%)	(N)	(N%)	(N)	(N%)	(N)	(N%)
Pseudomonas spp	4	11.4	8	19.0	3	8.3	2	8.0	3	17.6	20	12.9

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Staphylococcus aureus	13	37.1	8	19.0	6	16.7	3	12.0	_	41.2	30	19.4
Shigella spp	9	25.7	10	23.8	9	25.0	10	40.0	7	41.2	45	29.0
Serratia spp	9	25.7	10	23.8	9	25.0	10	40.0	7	_	45	29.0
Escherichia spp	_	_	2	4.8	3	8.3	_	_	_	_	5	3.2
Klebsiella spp	_	_	2	4.8	3	8.3	_	_	_	_	5	3.2
Enterobacter spp	_	_	2	4.8	3	8.3	_	_	_	_	5	3.2
Total	35		42		36		25		17		155	100.0
(N%)	22.58 %		27.1 %		23.23 %		16.13 %		10.97 %			

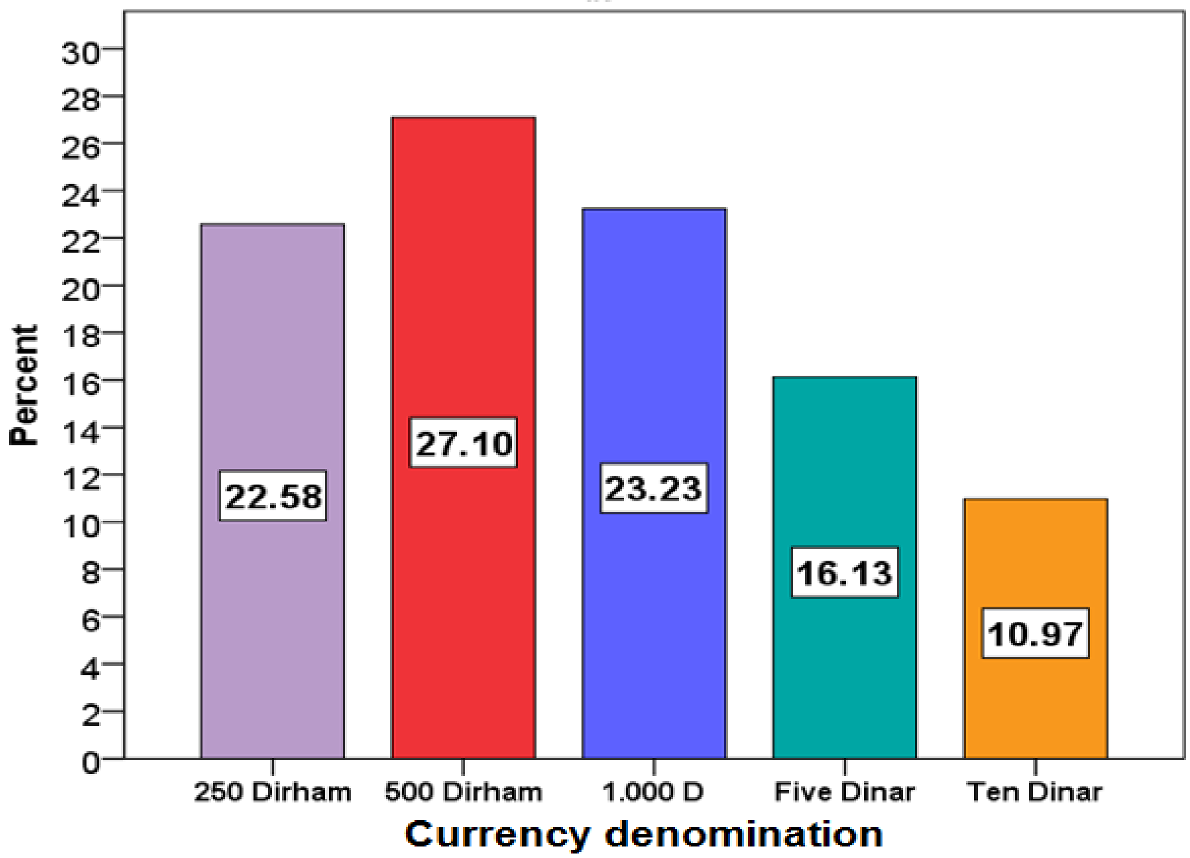

Figure 5. Percentage of bacterial isolates based on the currency notes denomination

The 250 Dirham notes included bacterial strains from four different species, with 37.1% of the germs belonging to *Staphylococcus aureus*. Of all the isolates found on these notes (250 Dirham), *Shigella spp.* and *Serratia spp.* contributed 25.7%, and *Pseudomonas spp.* contributed 11.3% (Figure 6).

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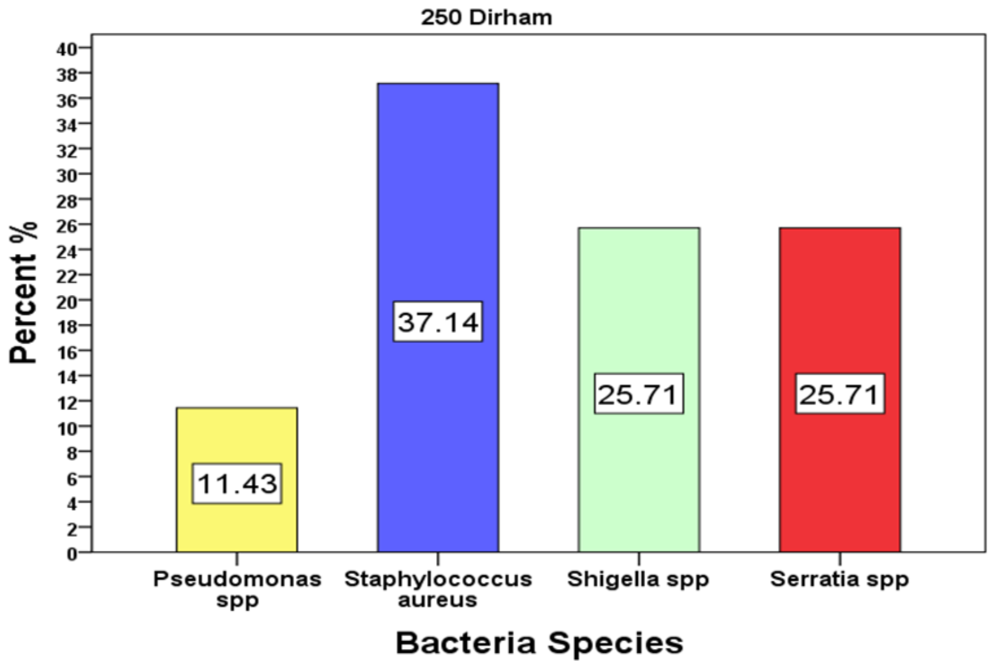

Figure 6. Percentage of bacterial isolates based on the 250 Dirham notes

Of the 500 Dirham notes, 7 bacterial species isolates were found, with 23.8% of them being *Serratia* and *Shigella spp.* Following it were *Staphylococcus aureus* and *Pseudomonas spp.* (19.0%), with 4.8% of the isolates detected on these notes (500 Dirham) consisting of *Escherichia spp.*, *Klebsiella spp.*, and *Enterobacter spp.* (Figure 7).

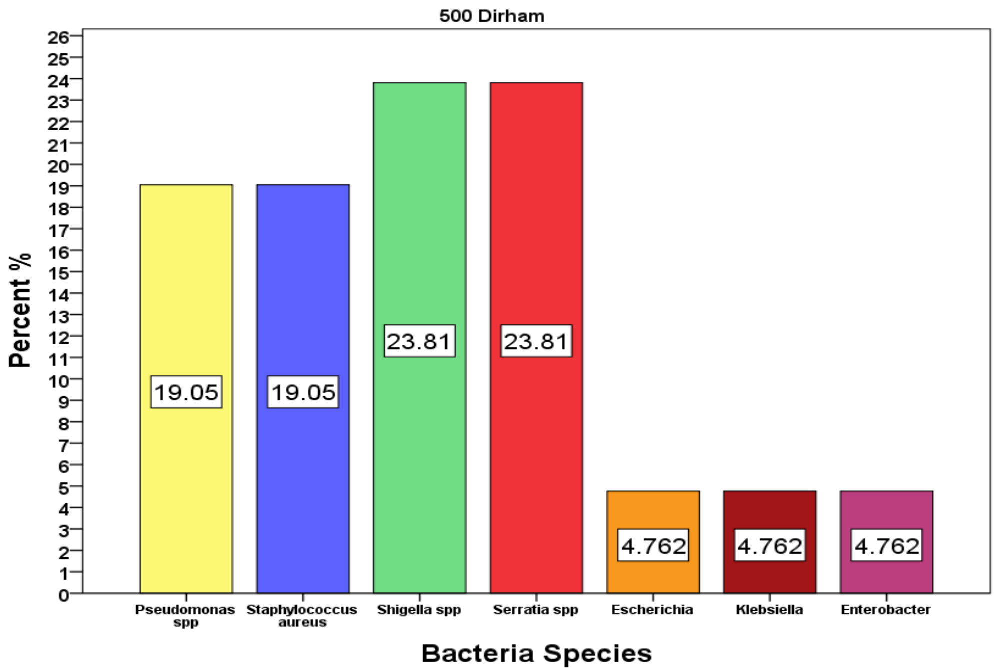

Figure 7. Percentage of bacterial isolates based on the 500 Dirham notes

In the banknote samples (1.000 D), *Shigella spp.* and *Serratia spp.* were the most often found bacteria, making about 25% of the total (Figure 8). *Staphylococcus aureus* (16.7%), *Escherichia spp.*, *Klebsiella spp.*, *Pseudomonas spp.*, and *Enterobacter spp.* (8.3%) were the other harmful microorganisms.

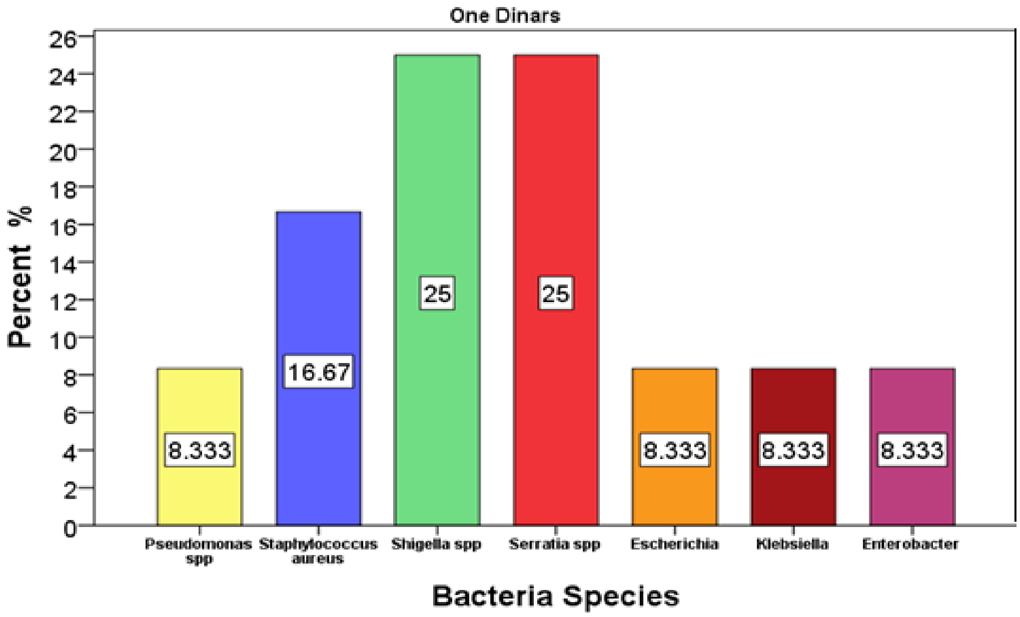

Figure 8. Percentage of bacterial isolates based on the 1.000 Dirham notes

The Five Dinar notes included bacterial isolates from four distinct species, of which 40.0% were *Shigella* and *Serratia species*. Of all the isolates found on these notes, *Staphylococcus aureus* (12%) and *Pseudomonas spp*. (8%) came next. Refer to Figure 9.

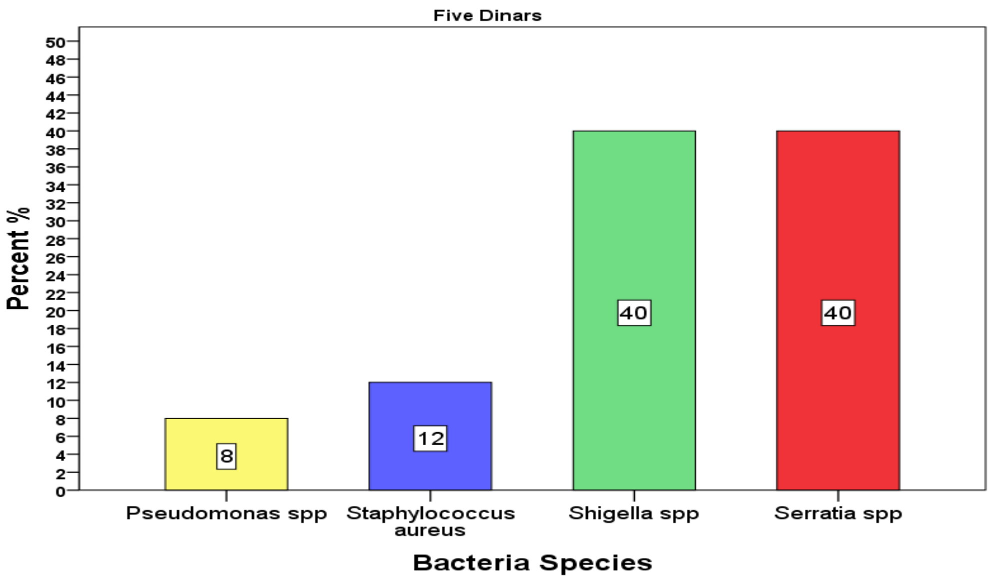

Figure 9. Percentage of bacterial isolates based on the Five Dinar notes

Of the bacterial isolates discovered in the Ten Dinar notes, 41.2% included strains of *Shigella* and *Serratia*. *Pseudomonas spp*. came next, accounting for 17.7% of all the isolates discovered on these notes. Refer to Figure 10.

The antibiotic susceptibility patterns of the isolated microorganisms are displayed in Table 5. According to antimicrobial sensitivity testing, the isolated bacteria were more susceptible to most antibacterial agents (86.3%) than resistant (13.7%) and when compared to pathogenic gram-positive isolates, the pathogenic gram-negative isolates showed greater resistance to the majority of antibacterial agents.

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Most of the bacteria that were found to be resistant to Amoxicillin 3%, Gentamicin 3%, Erythromycin 9%, Ciprofloxacin 89%, Amoxicillin/Clavulanic acid 81%, and Ampicillin/Cloxacillin 28% were insensitive to these antibiotics (Table 6).

Meanwhile, the majority of the bacteria were sensitive to these antibiotics at 97%, 97%, 91%, and 72% of them.

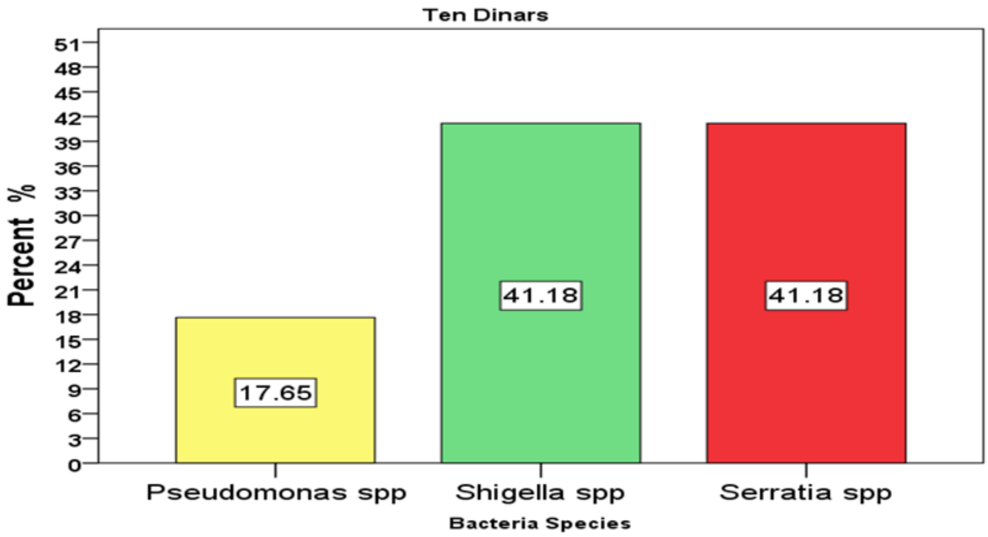

Figure 10. Percentage of bacterial isolates based on the Ten Dinar notes

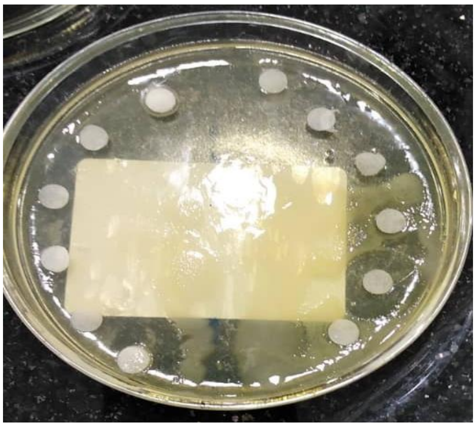

Figure 11. Antimicrobial susceptibility patterns of bacteria isolated

Table 5. Antibiotic sensitivity patterns of bacterial isolates from Libyan currency notes

Antibiotics	**Sensitivity**	
	R	**S**
	Count	**Count**
Ciprofloxacin	11	89
Gentamicin	3	97
Amoxicillin	3	97

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Erythromycin	9	91
Amoxicillin/Clavulanic acid	19	81
Ampicillin/Cloxacillin 20 mg	28	72
Total N (%)	13.7 %	86.3 %

Table 6. Antibiotic susceptibility to various bacteria isolated from different denominations of Libyan currency

Isolated bacteria	CIP		GEN		AMX		ERY		AMOXICLAV		AMPICLOX	
	R	S	R	S	R	S	R	S	R	S	R	S
Pseudomonas spp	2	12	1	13	1	13	2	12	3	11	4	10
Staphylococcus aureus	3	24	-	27	0	27	0	27	1	26	1	26
Shigella spp	2	23	-	25	0	25	2	23	6	19	7	18
Serratia spp	3	22	2	23	2	23	5	20	5	20	10	15
Escherichia spp	0	3	0	3	0	3	0	3	2	1	2	1
Klebsiella spp	0	3	0	3	0	3	0	3	1	2	3	0
Enterobacter spp	1	2	0	3	0	3	0	3	1	2	1	2
Total (N %)	11	89	3	97	3	97	9	91	19	81	28	72

ERY: erythromycin; CIP: ciprofloxacin; GEN: gentamicin; AMP: ampicillin; AMX: amoxicillin; AMOXICLAV: Amoxicillin/Clavulanic acid; AMPICLOX: Ampicillin/Cloxacillin.

4. Discussions

In the present study, several types of pathogenic bacteria that were isolated from coins and banknotes from Libya that had been tainted with pathogen bacterial strains are identified and counted. From the gathered samples, a total of 155 isolates belonging to seven distinct bacterial species were identified. Every Libyan coin and banknote analysed for this investigation contained germs.

This result was in agreement with the findings of Elsharief [15], Elemam [14], Firoozeh [16], in Libya, and Iran. It was also very comparable to previous research carried out in Ghana [17], [18], Saudi Arabia [19], and the United States of America [20]. Comparable results were also noted for banknotes from Nigeria [24], Nepal [23], South Africa [22], and Iraq [21]. Table 4 displayed the overall proportion of microbial isolates from the notes, with *Serratia* and *Shigella* species having the greatest bacterial percentage occurrence at 29.0%. *Staphylococcus aureus* was the second most common pathogen in the sample, accounting for 19.4% of the population. *Pseudomonas spp.* and other pathogenic organisms had 12.9%. With 3.2%, *Escherichia*, *Klebsiella*, and *Enterobacter species* were the least common. The results showed that figure 4 reflected these seven species' active involvement in order of percentage. The 500 Dirham notes were more often circulated (N=28) than the other monetary denominations under study. The results of this investigation also showed that lower value Libyan banknotes and coins were noticeably more polluted than higher denominations, supporting previous findings from investigations conducted in Ghana and Nigeria [25], [26], [27] implying that cross-contamination occurs often.

The results of this investigation demonstrated the frequency of bacterial contamination in the banknotes, suggesting that handling money carries some danger. Consequently, germs on banknotes may proliferate if they survive [28]. Additionally, they may result in food-borne infections, which is a reservoir for enteric diseases that is frequently disregarded [29], [30]. Overall, the money gathered for this study was discovered to be tainted with potentially harmful bacteria, including multiple strains linked to the intestines. These bacteria may also result in infections related to oral and dental healthcare, including *Staphylococcus aureus, Klebsiella,* and *Enterobacter* [31], [32]. Conversely, several of the isolated bacteria were found in the environment or in people's regular flora. It's possible that skin flake surfing or rubbing off caused *Staphylococcus aureus* to be present on money [33]. Libyan notes with enteric bacterial isolates are a sign of faecal contamination, which implies inadequate personal hygiene [34]. The 500 Dirham notes were linked to high bacterial burdens. Its dominance of the majority of everyday monetary transactions is probably the cause. Overall, the percentages in the 5.000 Dirham notes proved to be significantly lower than those in the other notes that were tested, indicating that there was less contamination and an incidence of harmful organisms in those notes than in the 250-, 500-, and 1.000-Dirham notes.

This investigation found no connection between the origins of Libyan coins and banknotes and microbiological contaminants. These dangerous bacteria's presence indicates that most individuals come into contact with tainted banknotes. Money kept in unclean settings and the habit of salivating on fingers when counting banknotes point to people as the primary source of bacteria on cash. Notes that are filthy or damaged pose a specific health risk since they are polluted. Furthermore, a variety of bacteria, some of which may be permanent, were present on unclean fingertips [35]. The most frequent causes of contamination were these behaviours, which included careless handling of cash while defecating, sneezing, and coughing [36]. Moreover, the materials used to make the money likely have an impact on the microbes' ability to survive on the banknotes [30]. Our research suggests that banknotes from Libya may be a means of spreading dangerous microorganisms. With unclean hands, users may trade Libyan coins and banknotes in a matter of minutes [37]. The isolation of all types of bacteria from Libyan banknotes and coins from coffee shops suggests that the hands of cafe employees may have been contaminated with faecal coliforms, which might lead to foodborne illnesses [38], [39]. Consumers who have dirty hands may be more likely to have illnesses linked to food [40]. Despite the fact that vegetables are known to harbour microorganisms, the frequency of bacterial contamination was lowest on Libyan banknotes and coins that were taken from vegetable stores.

According to this study, several of the germs that were recovered from Libyan coins and banknotes were resistant to common antibiotics. The best medication, nevertheless, to combat these bacterial isolates on the Libyan notes was amoxicillin. Similar results were obtained in Libya [14] and other regions of the world [41] by an earlier investigation. According to this study, there is a significant risk to public health because the Libyan notes include potentially dangerous bacterial isolates that are resistant to the majority of commonly used antibiotics. Overuse of the Libyan notes and unclean, unsanitary hands contaminate them with harmful microorganisms that might infect others handling them.

5. Conclusion

The study reveals that pathogenic germs were present in the Libyan cash that was collected, suggesting that Libyan banknotes may operate as a conduit for the spread of potentially dangerous pathogens. While there is no conclusive evidence linking the presence of bacteria on currency to infection, measures to prevent currency notes from becoming contaminated must be taken. For example, the central bank should regularly remove damaged notes, and credit card services may help stop the spread of bacteria. Furthermore, it is advised that people take better care of their own health by promptly washing their hands with soap and water after handling cash. To lessen the contamination, it is advised to heat sterilise cash or disinfect bank cash using UV light radiation. Saliva should not be used when counting money notes since it may increase the risk of infection. It is recommended that concerned authorities remove any tattered or worn-out cash since this might potentially cause contamination.

Public education about safe handling and preservation of cash is recommended in order to reduce currency contamination. In order to increase the spread of pathogenic bacteria among members of Libyan society, it is highly advised that more study on the topic be conducted on other Libyan places due to the lack of research on the contamination of currency notes with hazardous bacteria.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public or not-for-profit sectors.

Conflict of Interest

The authors declare that they have no conflict of interest.

Consent for Publication

The authors declare that they consented to the publication of this study.

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