MICROBIAL HAZARDS IN STREET FOODS: A COMPREHENSIVE STUDY IN DHAKA, BANGLADESH

Miraz Uddin Ahmed[1], Md. Iqbal Hossain[2], Md Abdul Ahad Maraj[3] & Mst. Mohona Islam[4]

[1]Junior Microbiologist, Popular Diagnostic Centre Ltd. Dhaka, Bangladesh
https://orcid.org/0009-0000-4933-6195
e-mail: mirazuddinahmed.primeasia.bd@gmail.com

[2]Lecturer, Department of Microbiology, Primeasia University, Dhaka, Bangladesh
https://orcid.org/0009-0005-9547-6910
e-mail: iqbalmbg31@gmail.com

[3]Graduate Researcher, Management Information Systems, College of Business, Lamar University, Beaumont, Texas, USA.
https://orcid.org/0009-0006-8708-0163
e-mail: mmaraj@lamar.edu

[4]Junior Microbiologist, Health and Hope Hospital. Dhaka, Bangladesh
https://orcid.org/0009-0002-1989-0747
e-mail: mohonaislam1611@gmail.com

Keywords

Street Foods
Dhaka City
Foodborne Pathogens
Antibiotic Resistanc
Bacteriological Quality
Public Health
E. coli
Klebsiella spp.
Pseudomonas spp.
Vibrio spp.
Staphylococcus Aureus

ABSTRACT

This study aimed to assess the bacteriological quality and antibiotic resistance of ready-to-eat street foods sold in various locations across Dhaka City. Eight samples were collected from different vendors and analyzed for the presence of foodborne pathogens and their resistance to antibiotics. The findings revealed significant contamination with *E. coli*, *Klebsiella spp.*, *Pseudomonas spp.*, *Vibrio spp.*, and *Staphylococcus aureus*. Total aerobic counts (TAC) ranged from 4.6 × 10^5 to 9.5 × 10^7 CFU/g, exceeding acceptable limits set by the International Commission for Microbiological Specifications for Foods (ICMSF). The total coliform count and Enterobacteriaceae count also showed alarmingly high levels. Antibiotic susceptibility tests indicated widespread resistance, particularly to Penicillin G, which was ineffective against all isolates. The results underscore the urgent need for improved food safety practices, regular inspections, and vendor education to mitigate the public health risks associated with street-vended foods in Dhaka City.

1 Heading

Street food, renowned worldwide for its vibrant array of textures and flavors, holds a unique place in culinary culture. Whether served hot or chilled, raw or cooked, these ready-to-eat delicacies are a staple of immediate consumption at the point of sale. The Food and Agriculture Organization (FAO) (2024) defines street food as ready-to-eat foods and beverages prepared or sold by vendors and hawkers, particularly in streets and other public spaces. According to The Food and Agriculture Organization (FAO) (2024), Street food, or fast food, is not just convenient and cheap, but it also holds a special place in the hearts and palates of people worldwide. The ingredient and making process of street food can be simple yet utterly delicious, and it's often a great way to sample some authentic local cuisine (Ajao & Atere, 2009). Fast food consumption has currently become a vital part of convenient food preparation patterns all over the world, including Bangladesh. The most popular consumed street food in Bangladesh is fuchka. However, the consumption of these ready-to-eat foods has been reported to be associated with serious health problems. The safety and microbiological quality of these food products have been raised nowadays. Foodborne illness is a widespread problem globally (Bhowmik, 2012). The presence of a wide range of foodborne diseases across developing countries bears the brunt of the problem in humans. Vendors generally use carts and stands, where they do not have easy access to running water. Furthermore, dish and hand washing are done using the same bucket, sometimes even without soap. Garbage and wastewater are usually discarded in the nearby streets, attracting and providing food for rodents and insects (The Center for Genetics, 2000).

Environmental conditions and practices like this often lead to contamination of cooked food. Vendors may purchase raw materials from doubtful sources that may either be contaminated with food-borne pathogens or be unfit for consumption for other reasons (World Health Organization, 2006). The consumption of these street foods potentially increases the risk of foodborne diseases caused by a wide variety of pathogens, which include *E. coli*, *Salmonella typhi*, *Pseudomonas spp.*, *Staphylococcus aureus*, *Clostridium perfringens*, *Campylobacter*, *Listeria monocytogenes*. The high prevalence of diarrhea diseases in many developing countries suggests major underlying food problems. Millions of people fall ill, and many suffer from severe disorders and long-term complications or die because of eating unsafe food. This is a pressing issue that demands immediate action (Kibret & Tadesse, 2013). Street food vendors, often unlicensed and untrained in food hygiene and sanitation, operate under unsanitary conditions, posing a significant threat to public health**.** Recent studies have indicated that ready-to-eat foods and food preparation surfaces may be reservoirs for microbial contamination.

Food and Agriculture Organization (FAO) (2024) further stipulates that street foods raise concern. FAO (2024) further stipulates that street foods raise concerns concerning their potential for severe food poisoning outbreaks due to improper use of additives, the presence of impurities, environmental contaminants, and improper food handling practices amongst street food vendors. Street foods in some African countries have been tested for various microorganisms of public health concern, including fecal coliforms, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* species, and *Bacillus cereus*. *Escherichia coli* and *Staphylococcus aureus klebshiella pneumonia*, *vibrio cholerae*, were recovered in a significant proportion of the food, water, hands, and surface swabs tested in Harare (Jaishankar et al., 2014). In Dhaka City, there is a moderate number of street food vendors. Those vendors gather mainly in the central business areas, at critical transport points such as train and bus stations, and in front of schools where many people buy these traditional foods (Shariatifar et al., 2020). Street vendors are usually poor, uneducated, and lack knowledge of food hygiene, handling, sanitation environment, food service, hand washing, source of raw materials, and portable water (Amare et al., 2019; Ekhator et al., 2017; Jaishankar et al., 2014). Since the popularity of street foods is increasing in the towns/cities and the country in general, this study was

Doi: 10.62304/ijhm.v1i3.158

OPEN ACCESS

Correspondence: Miraz Uddin Ahmed
Junior Microbiologist, Popular Diagnostic Centre Ltd. Dhaka, Bangladesh
e-mail:
mirazuddinahmed.primeasia.bd@gmail.

intended to assess the microbiological quality and antimicrobial resistance status of bacterial isolates from ready-to-eat foods sold by street vendors to ensure the health status of the consumers.

2 Literature Review

2.1 Microbial Analysis of Street Food

Vendors prepare and sell ready-to-eat foods or street foods on the street or in other public places. Street food consumption is a rapidly growing phenomenon in urbanized countries (Amare et al., 2019; Rane, 2011; Sridhar et al., 2021). High unemployment, low salaries and work opportunities, and social programs are common in developing and poor countries, and street food consumption is also high in these countries, as these types of foods are cheap, tasty, and readily available. Street foods are prepared and stored in dirty environments near contaminated sources, and most of the time, street foods are not covered and exposed to flies and dust, which cause food-borne diseases due to consumption (Rane, 2011). Potential health risks are associated with food contamination by Escherichia coli, Salmonella typhi, Pseudomonas species, Staphylococcus aureus, Proteus species, and other species during preparation, post-cooking, and handling stages. Street food vending has become a significant public health issue and a great concern. This is due to widespread foodborne diseases and the mushrooming of wayside food vendors who lack an adequate understanding of fundamental food safety issues (Sridhar et al., 2021). Various studies have identified the source of food safety issues involved in street foods to be microorganisms belonging to the genus Bacillus, Staphylococcus, Clostridium, Vibrio, Campylobacter, Listeria, and Salmonella.

2.2 Street Food Condition in Dhaka City, Bangladesh

Food vending is not abundant in number beside Dhaka City Street (Banik et al., 2018). Dhaka City has a central road, so most vendors run their business beside the main road. Food can easily be contaminated with different microbes, primarily enteric and dust (Al Mamun et al., 2013b). Education vendors are unable to maintain the primary food safety issue. Vendors do not have easy access to running water, so they wash their dishes in the same bucket, even without a shop (Ullah et al., 2017). Garbage and wastewater are typically discarded in the streets nearby, thus attracting and providing food for rodents and insects. Environmental conditions and practices like this often lead to contamination of cooked food. Vendors may purchase raw materials from doubtful sources, which may either be contaminated with food-borne pathogens or be unfit for consumption for other reasons (Al Mamun et al., 2013a; Muzaffar et al., 2009; Ullah et al., 2017).

2.3 Antimicrobial Resistance and Related Issues in Bangladesh

Different studies conducted in Bangladesh during the last decade revealed that there is polypharmacy, high use of antimicrobials, vitamins, and injectables in hospitals, and very low generic prescribing. Moreover, inadequate access to effective antimicrobials, incomplete therapy, and occasional but questionable quality of medicine negatively contributed to the emergence of resistance (Al Mamun et al., 2013b). Antimicrobial resistance is a mounting threat to controlling infectious diseases globally and locally in Bangladesh. During the last seventy years, the development of effective antimicrobials has reduced the incidence of life-threatening infections (Muzaffar et al., 2009). However, that achievement has been eroded by the emergence of resistance. Microbes developed resistance primarily in hospitals; however, they later spread in the community, imposing more risk to human health. Infections with resistant microbes result in more significant morbidity and mortality and increase health care costs. The loss of effectiveness of the antimicrobials leads to longer research durations and increased development expenses (Al Mamun et al., 2013a; Banik et al., 2018; Ullah et al., 2017).

3 Method

Eight samples of fuchka were aseptically collected from various food vendors across Dhaka City for this study. The collection sites included the Airport Railway Station, the vicinity in front of Zamuna Future Park, Uttara Sector 3, Badda, Bashundhara, Khilkhet, Banani, and Gulshan. Samples were placed in sterile zipper bags to prevent contamination and subsequently transported to the Department of Microbiology at Primeasia University. Solid samples were homogenized using a mortar and pestle, after which 10 grams of each sample were mixed with 90 mL of Peptone water broth for enrichment, and then incubated in a shaking incubator at 120 rpm for 24 hours. To isolate bacterial colonies, the samples were inoculated into non-selective nutrient agar media by spreading 100 µL of diluted sample onto the media, followed by incubation at 37°C for 24 hours. For selective isolation, samples were inoculated onto specific media, including MacConkey agar (selective for gram-negative bacteria), EMB agar (selective for *E. coli*), XLD agar (selective for *Salmonella spp.* and *Shigella spp.*), TCBS agar (selective for *Vibrio spp.*), MSA (selective for *Staphylococcus aureus*), and Cetrimide agar (selective for *Pseudomonas spp.*) using the streaking method. These plates were then incubated at 37°C for 24 hours. Enumeration of bacterial cells was performed using the serial dilution method, which provides faster and more accurate colony counting compared to the spread plate method. Identification of bacterial isolates involved gram staining, subculturing on nutrient and MacConkey agar, and a series of biochemical tests, including the TSI test, Indole test, Citrate Utilization test, Catalase test, Oxidase test, Methyl Red test, and Voges-Proskauer test. Antimicrobial susceptibility was assessed using the Kirby-Bauer disc diffusion method on Mueller Hinton agar with the antibiotics Ciprofloxacin (5 µg), Azithromycin (15 µg), Cephalexin (30 µg), and Penicillin G (10 IU). A sterile cotton swab dipped into the bacterial suspension was used to inoculate the agar plates, which were then incubated at 37°C for 24 hours. The inhibition zones were measured and interpreted according to the guidelines of the Clinical and Laboratory Standards Institute.

Table 1: Summary of the methodology for this study

Method/Procedure	Details
Collection of Samples	8 fuchka samples collected aseptically from various vendors in Dhaka City.
Location of Study Area	Airport Railway Station, in front of Zamuna Future Park, Uttara Sector 3, Badda, Bashundhara, Khilkhet, Banani, Gulshan.
Sample Collection and Transportation	Samples placed in sterile zipper bags, transported to Primeasia University, crushed, mixed with Peptone water broth, incubated.
Isolation of Bacterial Isolates	Non-selective media: Nutrient agar; Selective media: MacConkey, EMB, XLD, TCBS, MSA, Cetrimide; Incubation at 37˚C for 24 hours.
Enumeration of Bacterial Cells	Serial dilution method used for viable colony counting.
Identification of Isolates	Gram staining, subculturing, biochemical tests (TSI, Indole, Citrate Utilization, Catalase, Oxidase, Methyl Red, VP).
Antibiotic Susceptibility Assay	Kirby-Bauer disc diffusion on Mueller Hinton agar with Ciprofloxacin, Azithromycin, Cephalexin, Penicillin G; Zones measured and interpreted.

4 Findings

A total of eight samples of fuchka were aseptically collected from different food vendors in various locations across Dhaka City, including the Airport Railway Station, the area in front of Zamuna Future Park, Uttara Sector 3, Badda, Bashundhara, Khilkhet, Banani, and Gulshan. These samples were placed in sterile zipper bags to prevent contamination and subsequently transported to the Department of Microbiology at Primeasia U niversity. Upon arrival at the laboratory, solid samples were homogenized using a mortar and pestle, mixed with Peptone water broth, and incubated in a shaking incubator at 120 rpm for 24 hours to promote bacterial enrichment. For bacterial isolation, the samples were inoculated into non-selective nutrient agar media by spreading 100 µL of the diluted sample onto the media, followed by incubation at 37°C for 24 hours. For selective isolation, the samples were inoculated onto specific media, including MacConkey agar (selective for gram-negative bacteria), EMB agar (selective for *E. coli*), XLD agar (selective for *Salmonella spp.* and *Shigella spp.*), TCBS agar (selective for *Vibrio spp.*), MSA (selective for *Staphylococcus aureus*), and Cetrimide agar (selective for *Pseudomonas spp.*) using the streaking method. The plates were then incubated at 37°C for 24 hours.

.

Table 2: Antimicrobial agent, their disc concentration, and zone interpretative reference according

Antimicrobial Groups	Antimicrobial Agents	Disc conc.(µg)	Zone interpretation (diameter in mm)		
			S	**I**	**R**
Quinolones	Ciprofloxacin	5	≥21	16-20	≤15
Cephalosporin	Cephalexin	30	≥18	15-17	≤14
Penicillin	Penicillin G	10	≥17	14-16	≤13
Monobactams	Azithromycin	15	≥18	14-16	≤13

Note: S= Sensitive, I= Intermediate, R= Resistance

The enumeration of bacterial cells was conducted using the serial dilution method, which offers significant advantages in terms of faster and more accurate colony counting compared to the spread plate method. Bacterial isolates were identified through a combination of gram staining, subculturing on nutrient and MacConkey agar, and a series of biochemical tests including the TSI, Indole, Citrate Utilization, Catalase, Oxidase, Methyl Red, and Voges-Proskauer tests. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method on Mueller Hinton agar with antibiotic discs for Ciprofloxacin (5 µg), Azithromycin (15 µg), Cephalexin (30 µg), and Penicillin G (10 IU). The inoculated agar plates were incubated at 37°C for 24 hours. Inhibition zones were measured and interpreted in accordance with the guidelines of the Clinical and Laboratory Standards Institute. The sensitivity and resistance levels of the isolated bacteria to the tested antibiotics are depicted in Figure 1. The findings indicate that the majority of the isolates exhibited high resistance to Azithromycin and Penicillin G, with 100% resistance observed. In contrast, Ciprofloxacin demonstrated a mixed response with 28% sensitivity, 42% intermediate resistance, and 28% resistance. Cephalexin showed 14% intermediate resistance and 86% resistance. These results underscore the varying levels of antibiotic resistance among the bacterial isolates from the street food samples in Dhaka City (See Figure 1).

Figure 1: Antibiotics Sensitivity and Resistance

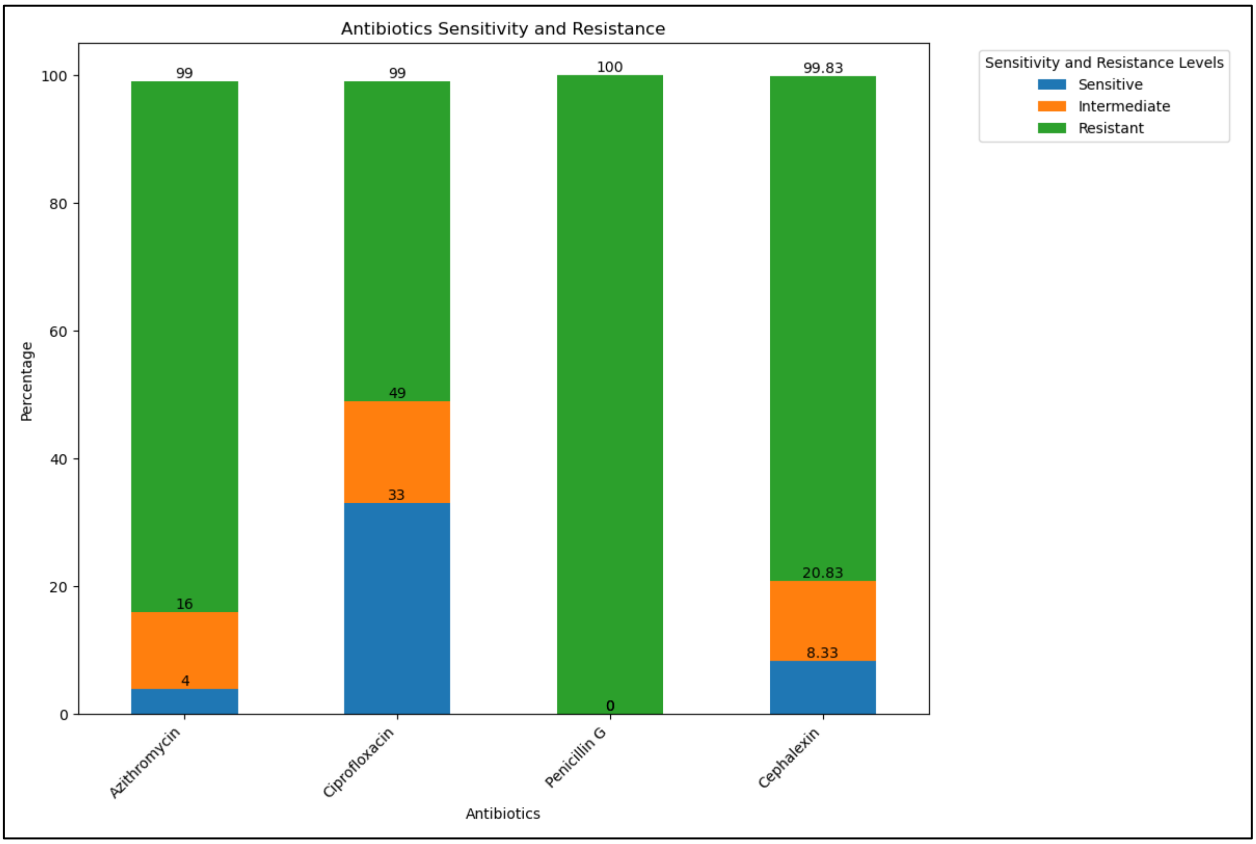


Table 3: Tabulated results of Biochemical test

Isolate ID	Gram Stain(s)	Presumptive Identification(s)
S1	(+) cocci, Rod (-)	Staphylococcus spp., Klebsiella spp.
S2	(+) cocci, Rods (-)	Staphylococcus spp., Klebsiella spp.
S3	(+) cocc, (-) Rods	Staphylococcus spp., Pseudomonas spp.
S4	(+) cocc, (-) Rods, (-) Rods	Staphylococcus spp., Klebsiella spp., Vibrio spp.
S5	(+) positive, (-) rods, (-) Rods	Staphylococcus spp., Klebsiella spp., Shigella spp.
S6	(+) cocci, (-) rods, (-) rods, (-) Rods	Staphylococcus spp., Klebsiella spp., Pseudomonas spp., Escherichia coli
S7	(-) cocci, (-) Rods, (-) Rods	Staphylococcus spp., Klebsiella spp., Shigella spp.
S8	(+) cocci, (-) Rods, (-) Rods, (-) Rods	Staphylococcus spp., Klebsiella spp., Shigella spp., Vibrio spp.

**S=Sample*

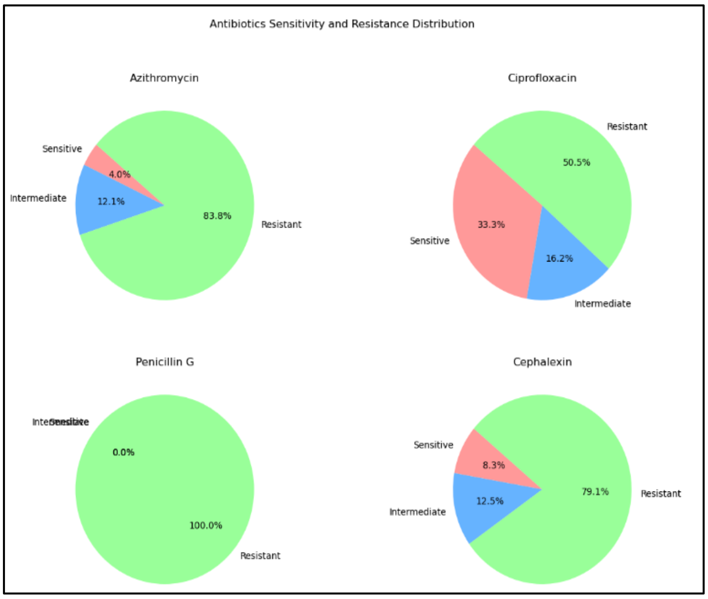
Doi: 10.62304/ijhm.v1i3.158

The biochemical tests conducted on bacterial isolates from street food samples in Dhaka City revealed a significant diversity of bacterial species, highlighting potential public health risks associated with the consumption of such foods. Isolate S1 exhibited a combination of Gram-positive cocci and Gram-negative rods, identified as Staphylococcus spp. and Klebsiella spp. Similarly, Isolate S2, showing the same Gram stain characteristics, was identified as Staphylococcus spp. and Klebsiella spp. Isolate S3 demonstrated the presence of both Gram-positive cocci and Gram-negative rods, leading to the presumptive identification of Staphylococcus spp. and Pseudomonas spp. In Isolate S4, the presence of Gram-positive cocci and two types of Gram-negative rods suggested a mixed population of Staphylococcus spp., Klebsiella spp., and Vibrio spp. Isolate S5, characterized by Gram-positive cocci and two types of Gram-negative rods, was identified as Staphylococcus spp., Klebsiella spp., and Shigella spp. In Isolate S6, a more diverse group was detected, including Gram-positive cocci and three types of Gram-negative rods, leading to the identification of Staphylococcus spp., Klebsiella spp., Pseudomonas spp., and Escherichia coli. Isolate S7 showed Gram-negative cocci and two types of Gram-negative rods, leading to the identification of Staphylococcus spp., Klebsiella spp., and Shigella spp. Finally, Isolate S8 displayed a complex mix of Gram-positive cocci and three types of Gram-negative rods, identified as Staphylococcus spp., Klebsiella spp., Shigella spp., and Vibrio spp. These findings underscore the importance of stringent hygiene practices and regular monitoring to ensure food safety, as multiple pathogenic bacteria were detected in these street food samples.

Table 4: Mean bacterial colony unit of ready to eat street foods (fuchka) against the standard Dhaka

Food Item	Region 1	Region 2	Region 3
S1	2.50×10^3	1.80×10^5	2.00×10^5
S2	5.70×10^3	2.90×10^5	5.00×10^7
S3	3.50×10^3	2.70×10^5	1.50×10^7
S4	5.00×10^1	3.00×10^3	3.00×10^5
S5	5.02×10^3	4.07×10^5	1.50×10^7
S6	4.00×10^3	2.80×10^5	2.00×10^7
S7	6.00×10^3	5.20×10^5	3.00×10^7
S8	6.50×10^3	4.50×10^5	3.70×10^7

Figure 2: Antibiotic Susceptibility Test Result/finding Graph



The study's findings indicate a high level of antibiotic resistance among the 24 pathogenic isolates tested from street food samples in Dhaka City. Specifically, 83% of the isolates demonstrated resistance to Azithromycin, with only 12.1% exhibiting intermediate resistance and a minimal 4% being sensitive. Ciprofloxacin showed a varied response, with 50% of the isolates being resistant, 16.7% intermediate, and 33.3% sensitive. Penicillin G exhibited the most alarming results, with 100% of the isolates showing resistance, highlighting its ineffectiveness against these pathogens. Cephalexin also presented significant resistance, with 79.1% of the isolates being resistant, 12.5% intermediate, and only 8.3% sensitive. These results, depicted in Figure 2 through a series of pie charts, emphasize the widespread issue of antibiotic resistance among foodborne pathogens in Dhaka City. This high level of resistance underscores the urgent need for stringent monitoring and regulation of antibiotic use to mitigate the risk of spreading resistant bacterial strains through street food. The consistent resistance patterns across multiple antibiotics suggest a pressing public health concern that necessitates immediate attention and action to ensure food safety and protect public health.

Figure 3: Antibiotics Sensitivity and Resistance Distribution

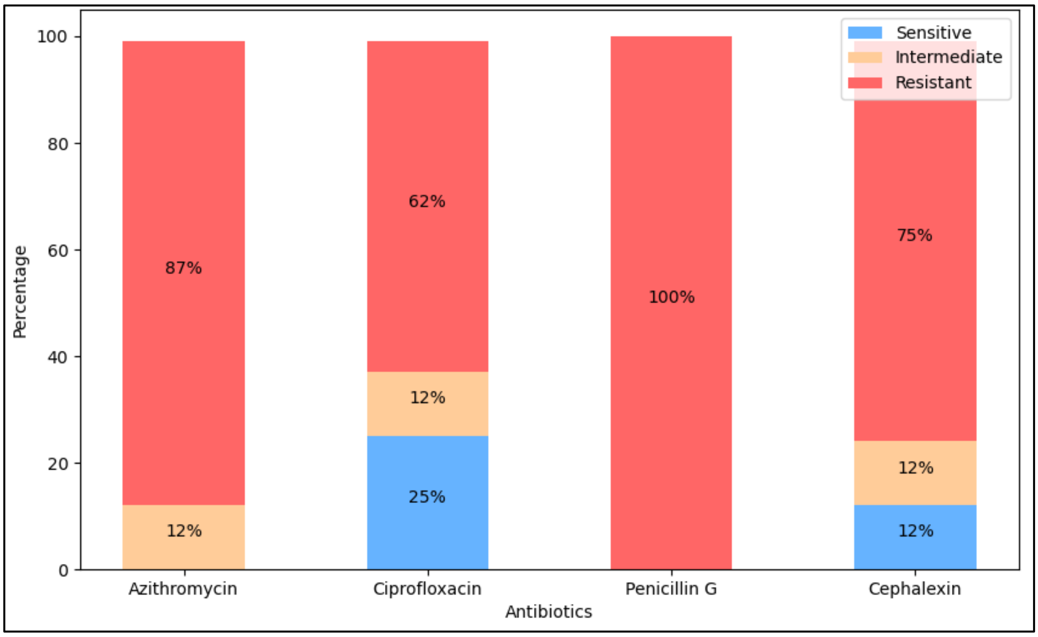
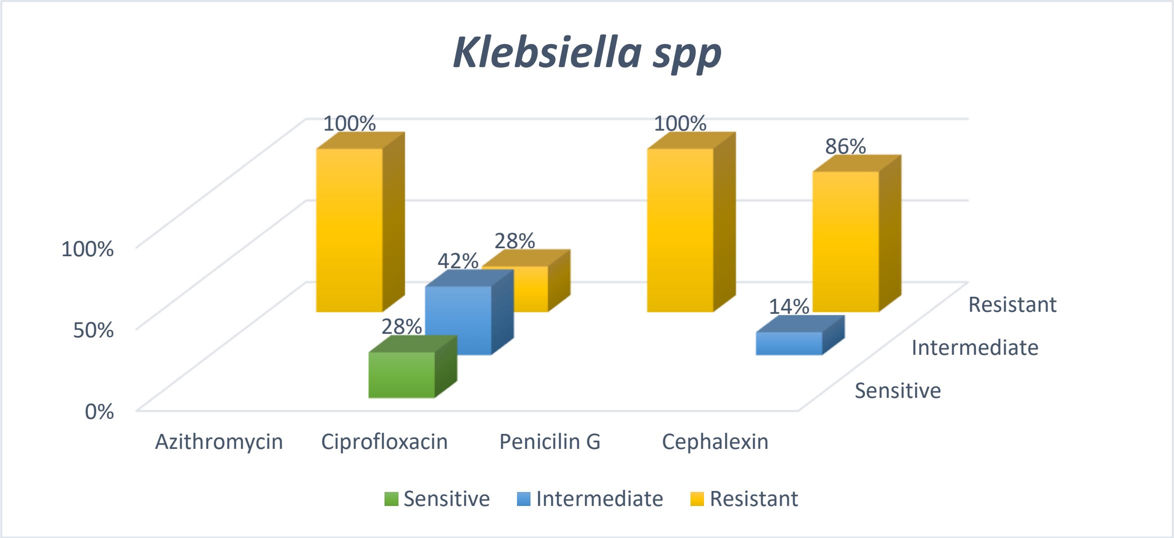


Figure 4: Klebsiella spp



The study's findings revealed a significant level of antibiotic resistance among the bacterial isolates obtained from street food samples in Dhaka City, particularly highlighting the resistance patterns of *Staphylococcus spp. and Klebsiella spp*. As illustrated in Figure 3, all eight isolates of *Staphylococcus spp.* demonstrated 87% resistance to Azithromycin, 62% resistance to Ciprofloxacin, 100% resistance to Penicillin G, and 75% resistance to Cephalexin. These alarming resistance rates underscore the pressing need for stringent antibiotic regulation and monitoring. Furthermore, as shown in Figure 4, *Klebsiella spp.* exhibited complete (100%) resistance to both Azithromycin and Penicillin G, while 86% of the isolates were resistant to Cephalexin and 28% to Ciprofloxacin. The intermediate resistance levels were observed at 12% for Azithromycin and Cephalexin, and 42% for Ciprofloxacin. The study's comprehensive analysis of antibiotic resistance patterns emphasizes the urgent public health challenge posed by the widespread prevalence of resistant bacterial strains in street food, necessitating immediate interventions to ensure food safety and mitigate the spread of resistant pathogens.

Figure 5: Vibrio Spp

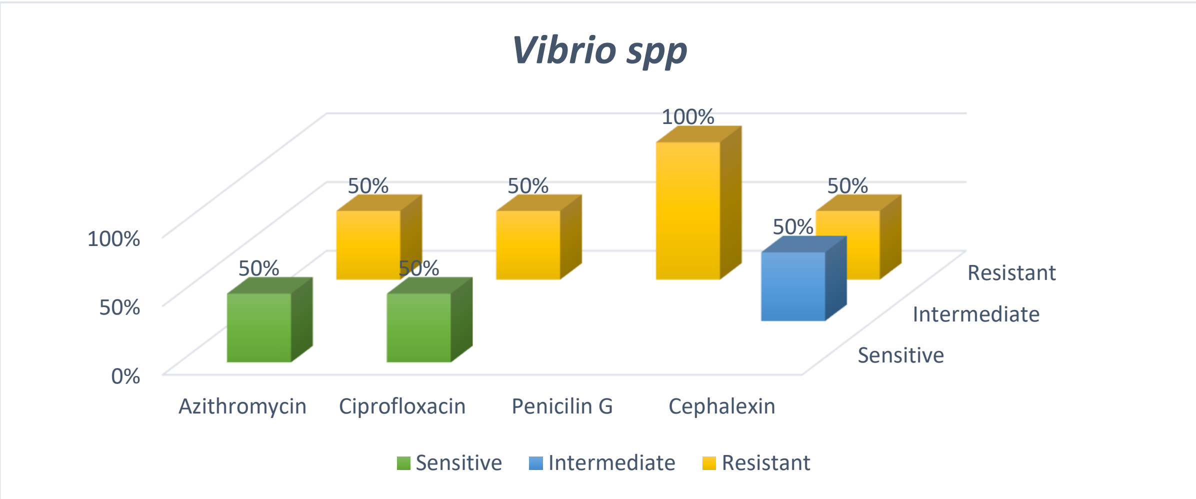
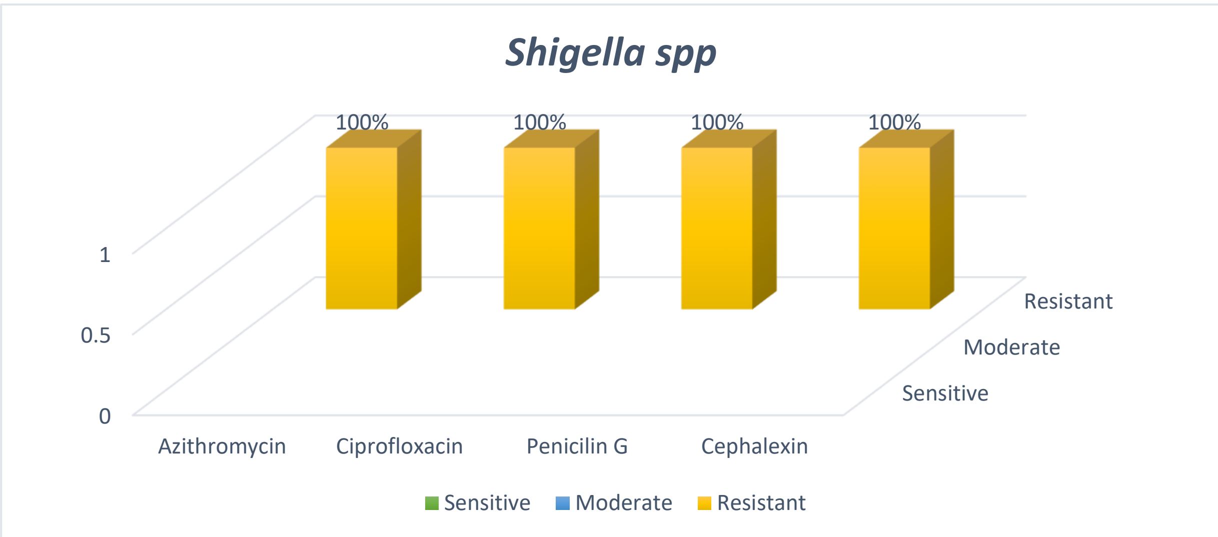


Figure 6: Shigella spp



The study's findings indicate a significant level of antibiotic resistance among various bacterial isolates obtained from street food samples in Dhaka City. Specifically, *Staphylococcus spp.* isolates demonstrated 87% resistance to Azithromycin, 62% resistance to Ciprofloxacin, 100% resistance to Penicillin G, and 75% resistance to Cephalexin, highlighting a considerable resistance to commonly used antibiotics (Figure 3). Furthermore, Klebsiella spp. exhibited 100% resistance to both Azithromycin and Penicillin G, 86% resistance to Cephalexin, and 28% resistance to Ciprofloxacin, with intermediate resistance observed at 42% for Ciprofloxacin and 12% for both Azithromycin and Cephalexin (Figure 4). Additionally, *Vibrio spp.* showed 50% resistance and 50% sensitivity to Azithromycin and Ciprofloxacin, 50% resistance to Penicillin G, and a mixed response to Cephalexin with 50% resistance, 50% intermediate, and 50% sensitivity (Figure 5). On the other hand, *Shigella spp.* demonstrated 100% resistance to Azithromycin, Ciprofloxacin, Penicillin G, and Cephalexin, indicating a complete lack of effectiveness of these antibiotics against this pathogen (Figure 6). These findings underscore the critical public health challenge posed by the high prevalence of antibiotic-resistant bacteria in street food, necessitating stringent monitoring, regulation of antibiotic use, and enhanced hygiene practices to mitigate the spread of resistant pathogens.

Figure 7: Escherichia Coli

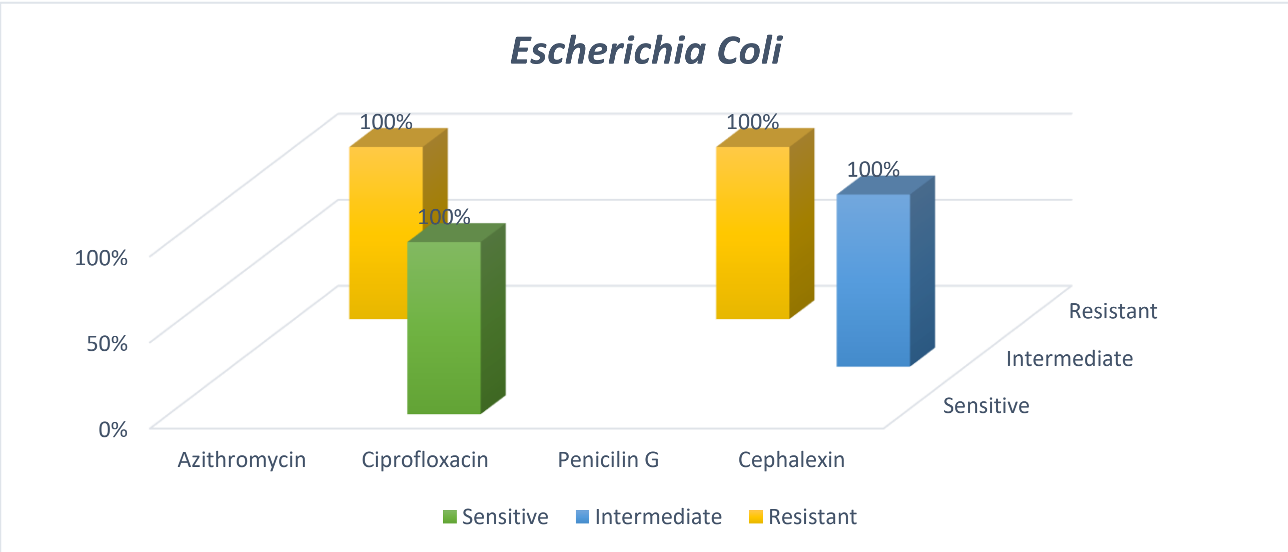


Table 5: Antibiotic susceptibility test result

SN	Sample Name	Organism	Azithromycin			Ciprofloxacin			Penicilin G			Cephalexin		
		Zone interpretation	≥18	14-16	≤13	≥21	16-20	≤15	≥17	14-16	≤13	≥18	15-17	≤14
			S	M	R	S	M	R	S	M	R	S	M	R
1	S1	*Staphylococcus spp*		R			22mm			R			26mm	
2	S1	*Klebsiella spp*		10mm			23mm			R			10mm	
3	S2	*Staphylococcus spp*		15mm			18mm			R			R	
4	S2	*Klebsiella spp*		8.5mm			21mm			R			R	
5	S3	*Staphylococcus spp*		R			R			R			R	
6	S3	*Pseudomonas spp*		16mm			28mm			R			R	

7	S4	*Staphylococcus spp*	R	R	R	R
8	S4	*Vibrio spp*	19mm	33mm	8mm	25mm
9	S4	*Klebsiella spp*	9mm	20mm	R	11mm
10	S5	*Shigella spp*	R	R	R	R
11	S5	*Klebsiella spp*	9 mm	20mm	R	R
12	S5	*Staphylococcus spp*	R	25mm	R	17.5mm
13	S6	*Shigella spp*	R	R	R	R
14	S6	*Staphylococcus spp*	R	R	R	R
15	S6	*Klebsiella spp*	R	R	R	15mm
16	S6	*Escherichia Coli*	11mm	22mm	R	15
17	S6	*Pseudomonas spp*	14mm	30mm	R	R
18	S7	*Shigella spp*	R	R	R	R
19	S7	*Klebsiella spp*	9.5mm	13.5mm	R	R
20	S7	*Staphylococcus spp*	R	R	R	R
21	S8	*Staphylococcus spp*	R	R	R	R
22	S8	*Vibrio spp*	R	R	R	R
23	S8	*Shigella spp*	R	R	R	R
24	S8	*Klebsiella spp*	10mm	18mm	R	13mm

The antibiotic susceptibility tests performed on various bacterial isolates from street food samples in Dhaka City revealed significant resistance patterns. Staphylococcus spp. isolated from Sample S1 showed resistance to Azithromycin and Cephalexin, but was sensitive to Ciprofloxacin (22mm) and resistant to Penicillin G. In the same sample, Klebsiella spp. exhibited resistance to Azithromycin, sensitivity to Ciprofloxacin (23mm), and resistance to both Penicillin G and Cephalexin. For Sample S2, Staphylococcus spp. showed intermediate resistance to Ciprofloxacin (15mm), sensitivity to Cephalexin (18mm), and resistance to Azithromycin and Penicillin G, while Klebsiella spp. showed resistance to Azithromycin, intermediate resistance to Ciprofloxacin (21mm), and resistance to Penicillin G and Cephalexin. In Sample S3, Staphylococcus spp. was resistant to all antibiotics tested, whereas Pseudomonas spp. displayed intermediate resistance to Azithromycin (16mm), sensitivity to Ciprofloxacin (28mm), and resistance to Penicillin G and Cephalexin. Staphylococcus spp. in Sample S4 was resistant to all antibiotics, while Vibrio spp. showed sensitivity to Ciprofloxacin (33mm) and Cephalexin (25mm), resistance to Azithromycin (19mm), and intermediate resistance to Penicillin G (8mm). In the same sample, Klebsiella spp. exhibited resistance to Azithromycin, intermediate resistance to Ciprofloxacin (20mm), and resistance to Penicillin G and Cephalexin. Shigella spp. in Sample S5 was resistant to all antibiotics, whereas Klebsiella spp. in the same sample was resistant to Azithromycin, intermediate to Ciprofloxacin (20mm), and resistant to Penicillin G and Cephalexin. For Sample S6, Shigella spp. and Staphylococcus spp. were resistant to all antibiotics, while Klebsiella spp. showed resistance to Azithromycin, Ciprofloxacin, and Penicillin G, but intermediate resistance to Cephalexin (15mm). Escherichia coli in Sample S6 exhibited intermediate resistance to Azithromycin (11mm), sensitivity to Ciprofloxacin (22mm), and resistance to Penicillin G and Cephalexin. Pseudomonas spp. in the same sample displayed intermediate resistance to Azithromycin (14mm), sensitivity to Ciprofloxacin (30mm), and resistance to Penicillin G and Cephalexin. Shigella spp. in Sample S7 was resistant to all antibiotics, whereas Klebsiella spp. in the same sample exhibited resistance to Azithromycin and Penicillin G, intermediate resistance to Ciprofloxacin (13.5mm), and resistance to Cephalexin. Finally, Staphylococcus spp. in Sample S8 was resistant to all antibiotics, while Vibrio spp., in the same sample showed complete resistance to all antibiotics tested. These findings highlight a concerning level of antibiotic resistance among bacterial isolates from street food, emphasizing the need for stringent monitoring and regulation to ensure public health safety.

5 Discussion

The findings from this study reveal a significant public health concern regarding the high levels of antibiotic resistance observed in bacterial isolates from street food samples in Dhaka City (Al Mamun et al., 2013a; Muzaffar et al., 2009). The resistance patterns varied across different bacteria and antibiotics, indicating a complex and multifaceted issue that requires immediate attention. Notably, *Staphylococcus spp.* showed widespread resistance to multiple antibiotics, with 87% resistance to Azithromycin, 62% resistance to Ciprofloxacin, 100% resistance to Penicillin G, and 75% resistance to Cephalexin. These resistance levels are alarming, especially considering that *Staphylococcus spp.* is a common pathogen associated with foodborne illnesses and can cause a range of infections from minor skin conditions to severe systemic diseases. The high resistance to Penicillin G, in particular, is concerning given its historical significance as one of the first antibiotics used in clinical settings. This resistance suggests that *Staphylococcus spp.* in street food has potentially been exposed to significant antibiotic pressure, leading to the selection of resistant strains.

Klebsiella spp., another significant pathogen, demonstrated complete resistance (100%) to Azithromycin and Penicillin G, with substantial resistance to Cephalexin (86%) and intermediate resistance to Ciprofloxacin (42%). The presence of such high resistance levels in *Klebsiella spp.* is particularly troubling given its role in causing severe infections, including pneumonia, bloodstream infections, wound infections, and meningitis. The ability of *Klebsiella spp.* to acquire resistance through horizontal gene transfer further complicates the issue, as it can spread resistance genes to other bacteria, exacerbating the problem of antibiotic resistance in the community.

The resistance patterns observed in *Vibrio spp.* and *Shigella spp.* also underscore the critical public health risks associated with street food. *Vibrio spp.* showed mixed resistance patterns, with 50% resistance to Azithromycin and Ciprofloxacin, 100% resistance to Penicillin G, and a combination of 50% resistance, 50% intermediate, and 50% sensitivity to Cephalexin. This variability indicates that while some strains of *Vibrio spp.* may still be treatable with certain antibiotics, there is a significant presence of resistant strains that could pose treatment challenges. Similarly, *Shigella spp.* exhibited complete resistance (100%) to all tested antibiotics, highlighting an urgent need for alternative treatment strategies and rigorous control measures to prevent the spread of these highly resistant strains.

Escherichia coli, another key pathogen identified in the samples, displayed complete resistance to Penicillin G, high resistance to Cephalexin (100%), and intermediate resistance to Azithromycin (11mm). The sensitivity to Ciprofloxacin (22mm) offers some hope for treatment, but the overall high resistance levels suggest that *E. coli* strains present in street food are becoming increasingly difficult to manage with standard antibiotic therapies. This pattern of resistance in *E. coli* is particularly concerning given its ubiquity and potential to cause a wide range of infections, from urinary tract infections to severe gastrointestinal diseases.

The observed resistance trends underscore the importance of implementing stringent monitoring and regulatory frameworks to manage antibiotic use, especially in the context of street food vendors who may not adhere to strict hygiene practices. The study highlights the urgent need for public health interventions, including education on proper food handling and preparation, routine surveillance of antibiotic resistance patterns, and the development of guidelines to minimize the misuse and overuse of antibiotics. Addressing these challenges requires a coordinated effort involving public health authorities, food safety regulators, healthcare providers, and the community to effectively combat the growing threat of antibiotic-resistant bacteria in the food supply.

It was also found that 100% of the food samples were contaminated with foodborne pathogens, including *E.*

coli, *Klebsiella spp.*, *Pseudomonas spp.*, *Vibrio spp.*, and *Staphylococcus aureus*. The total aerobic count (TAC) in these samples ranged from 4.6×10^5 to 9.5×10^7 CFU/g, which is higher than the counts reported in other regions: 1.10 to 3.61×10^5 CFU/g in Gondar, Ethiopia (Fenta, 2018), 2.98×10^3 to 4.09×10^4 CFU/g in Lagos, Nigeria (Adegoke et al., 2018), and 12.16 to 25.81×10^5 CFU/g in Tirumala, India (Kumari et al., 2017). The total aerobic counts of samples from all the tested street-vended locations were not within the acceptable limit recognized by the International Commission for Microbiological Specifications for Foods (ICMSF), which is 10^6 to $< 10^7$ CFU/g (ICMSF, 2002). These variations can be largely attributed to differences in food contents, methods of preparation, personal hygiene, and the ways vendors handle and serve the food. Additionally, the diversity in environmental climatic conditions could also explain the observed differences.

In our study, the total coliform count ranged from 8×10^5 to 9.2×10^7 CFU/g, which is much higher than the 3×10^2 to 6.4×10^3 CFU/g reported in Gondar (Tadesse & Tessema, 2018) and the 2.8×10^2 to 3.99×10^3 CFU/g reported in Tirumala, India (Rao et al., 2017). Similarly, the Enterobacteriaceae count of 1.3×10^4 to 3.3×10^7 CFU/g observed in this study exceeds the counts reported in other studies: 1.0 to 4.7×10^4 CFU/g in Accra, Ghana (Mensah et al., 2012) and 6×10 to 8×10^2 CFU/g in Egypt (El-Sherbeeny et al., 2017).

Post-processing contamination and poor hygienic conditions of vendors and their vending vicinity could be possible reasons for the observed high coliform and Enterobacteriaceae counts in this study (Al Mamun et al., 2013b). Enteropathogens are known to survive on the hands for three hours or longer, indicating that the isolation of these organisms suggests fecal contamination of the foods, as suggested by Ullah et al. (2017). Defective personal hygiene can facilitate the transmission of these pathogens via food to humans. Additionally, *Enterobacter spp.*, *Serratia spp.*, and *Shigella spp.* are implicated in many diseases, including gastroenteritis (Rane, 2011). The presence of members of the family Enterobacteriaceae in food products is usually seen as a health risk to the microbial safety of the food. This study also showed antibacterial resistance against different pathogens (Gupta et al., 2022; Mehra et al., 2021; Rane, 2011).

Street foods are very popular in developing countries due to their low cost and appealing taste. Millions of people consume street foods like fruit juices, meals, snacks, etc., every day. Foodborne illnesses of microbial origin are a major health problem associated with street foods. Approximately 30 million people in Bangladesh suffer from foodborne illnesses each year (Al Mamun et al., 2013b; Khairuzzaman et al., 2014; Rakha et al., 2022). The increased global flow of antimicrobials has brought the threat of antimicrobial resistance. Many governmental and agency reports have been published regarding the resistance of antibiotics (Al Mamun et al., 2013a; Ekhator et al., 2017). Various studies show that antimicrobials are frequently misused and overused in many developing countries, leading to an increase in morbidity, mortality, and healthcare costs (Alimi, 2016; Kibret & Tadesse, 2013; Steyn et al., 2013).

The objective of this research was to focus on the sensitivity of different classes of antibiotics against different enteric bacteria found in street and expired food. According to our findings, Penicillin G showed resistance in all 24 isolates, indicating it is no longer effective, as bacteria can grow even in the presence of the drug. This highlights the ineffectiveness of certain antibiotics in our present study. Twenty-four isolates were tested with four antibiotics to evaluate antibacterial sensitivity. The standard chart of the zone of inhibition was used to categorize the bacteria as resistant, intermediate, or susceptible. Penicillin G was found to be resistant, showing no zone of inhibition (Ajao & Atere, 2009; Amare et al., 2019; Bhowmik, 2012; Kiani et al., 2021; Shariatifar et al., 2020; The Center for Genetics, 2000; The Food and Agriculture Organization (FAO), 2024; World Health Organization, 2006). Azithromycin, Cephalexin, and Ciprofloxacin were found to be intermediate antibiotics. An excellent result was observed against the microbes when treated with Ciprofloxacin. There were limitations in this study, as only four antibiotics were used to assess antimicrobial sensitivity due to limited methods and facilities.

6 Conclusion:

This study demonstrated that street-vended foods sold in the Dhaka city region were considerably contaminated with foodborne bacteria, and antibiotic-resistant isolates were prevalent, indicating that street foods might pose a significant public health problem. The findings suggest that lack of training on proper food handling and processing, poor personal hygiene among vendors, and unhygienic surroundings are possible factors contributing to the observed contamination. To address these issues, it is essential to provide education for vendors on food safety and hygienic practices to reduce the contamination rate. Additionally, regular inspection of food vending practices and the safety of street foods is necessary to improve the health standards for consumers. The study highlights the urgent need for stringent measures to ensure the microbial safety of street foods to protect public health in the region.

Reference

Ajao, A., & Atere, T. (2009). Bacteriological assessment and hygienic standard of food canteens in Kwara State Polytechnic, Ilorin, Nigeria. *African Scientist Journal*, *3*(10), 173-180.

Al Mamun, M., Rahman, S. M. M., & Turin, T. C. (2013a). Knowledge and awareness of children's food safety among school-based street food vendors in Dhaka, Bangladesh. *Foodborne pathogens and disease*, *10*(4), 323-330.

Al Mamun, M., Rahman, S. M. M., & Turin, T. C. (2013b). Microbiological quality of selected street food items vended by school-based street food vendors in Dhaka, Bangladesh. *International journal of food microbiology*, *166*(3), 413-418.

Alimi, B. A. (2016). Risk factors in street food practices in developing countries: A review. *Food Science and Human Wellness*, *5*(3), 141-148. https://doi.org/10.1016/j.fshw.2016.05.001

Amare, A., Worku, T., Ashagirie, B., Adugna, M., Getaneh, A., & Dagnew, M. (2019). Bacteriological profile, antimicrobial susceptibility patterns of the isolates among street vended foods and hygienic practice of vendors in Gondar town, Northwest Ethiopia: a cross sectional study. *BMC microbiology*, *19*(1), 120-120. https://doi.org/10.1186/s12866-019-1509-4

Banik, A., Abony, M., Datta, S., & Towhid, S. T. (2018). Microbial status and multidrug resistance pattern of pathogenic bacteria isolated from street food in Dhaka city, Bangladesh. *Journal of Advances in Microbiology*, *13*(1), 1-13.

Bhowmik, S. (2012). *Street vendors in the global urban economy*. Taylor & Francis.

Ekhator, O. C., Udowelle, N. A., Igbiri, S., Asomugha, R. N., Igweze, Z. N., & Orisakwe, O. E. (2017). Safety Evaluation of Potential Toxic Metals Exposure from Street Foods Consumed in Mid-West Nigeria. *Journal of environmental and public health*, *2017*(NA), 8458057-8458057. https://doi.org/10.1155/2017/8458057

Gupta, N., Yadav, K. K., Kumar, V., Prasad, S., Cabral-Pinto, M. M. S., Jeon, B.-H., Kumar, S., Abdellattif, M. H., & Alsukaibia, A. K. D. (2022). Investigation of Heavy Metal Accumulation in Vegetables and Health Risk to Humans From Their Consumption. *Frontiers in Environmental Science*, *10*(NA), NA-NA. https://doi.org/10.3389/fenvs.2022.791052

Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B. B., & Beeregowda, K. N. (2014). Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary toxicology*, *7*(2), 60-72. https://doi.org/10.2478/intox-2014-0009

Khairuzzaman, M., Chowdhury, F. M., Zaman, S., Al Mamun, A., & Bari, M. L. (2014). Food safety challenges towards safe, healthy, and nutritious street foods in Bangladesh. *International journal of food science*, *2014*.

Kiani, A., Arabameri, M., Moazzen, M., Shariatifar, N., Aeenehvand, S., Khaniki, G. J., Abdel-Wahhab, M. A., & Shahsavari, S. (2021). Probabilistic Health Risk Assessment of Trace Elements in Baby Food and Milk Powder Using ICP-OES Method. *Biological trace element research*, *200*(5), 1-12. https://doi.org/10.1007/s12011-021-02808-w

Kibret, M., & Tadesse, M. (2013). The bacteriological safety and antimicrobial susceptibility of bacteria isolated from street-vended white lupin (Lupinus albus) in Bahir Dar, Ethiopia. *Ethiopian Journal of Health Sciences*, *23*(1), 19-26.

Mehra, R., Kumar, S., Verma, N., Kumar, N., Singh, R., Bhardwaj, A., Nayan, V., & Kumar, H. (2021). Chemometric approaches to analyze the colostrum physicochemical and immunological (IgG) properties in the recently registered

Himachali Pahari cow breed in India. *LWT*, *145*(NA), 111256-NA. https://doi.org/10.1016/j.lwt.2021.111256

Muzaffar, A. T., Huq, I., & Mallik, B. A. (2009). Entrepreneurs of the streets: An analytical work on the street food vendors of Dhaka City. *International journal of Business and Management*, *4*(2), 80-88.

Rakha, A., Fatima, M., Bano, Y., Khan, M. A., Chaudhary, N., & Aadil, R. M. (2022). Safety and quality perspective of street vended foods in developing countries. *Food Control*, *138*(NA), 109001-109001. https://doi.org/10.1016/j.foodcont.2022.109001

Rane, S. (2011). Street Vended Food in Developing World: Hazard Analyses. *Indian journal of microbiology*, *51*(1), 100-106. https://doi.org/10.1007/s12088-011-0154-x

Shariatifar, N., Rezaei, M., Sani, M. A., Alimohammadi, M., & Arabameri, M. (2020). Assessment of Rice Marketed in Iran with Emphasis on Toxic and Essential Elements; Effect of Different Cooking Methods. *Biological trace element research*, *198*(2), 721-731. https://doi.org/10.1007/s12011-020-02110-1

Sridhar, K., Dikkala, P. K., Yadla, A. K., Shaik, R., Jeepalem, Y., Dhoolipalla, V. B. P., & Sodadasi, V. (2021). Preparation of microwave-processed oil-free potato snacks with assorted natural flavours: Application of advanced chemometrics. *International Journal of Food Science & Technology*, *57*(6), 3303-3310. https://doi.org/10.1111/ijfs.15214

Steyn, N. P., McHiza, Z., Hill, J., Davids, Y. D., Venter, I., Hinrichsen, E., Opperman, M., Rumbelow, J., & Jacobs, P. (2013). Nutritional contribution of street foods to the diet of people in developing countries: a systematic review. *Public health nutrition*, *17*(6), 1363-1374. https://doi.org/10.1017/s1368980013001158

The Center for Genetics, N. a. H. (2000). *World Review of Nutrition and Dietetics*.

The Food and Agriculture Organization (FAO). (2024). *The state of food security and Nutrition in the world*. https://www.fao.org/about/about-fao/en/

Ullah, A. K. M. A., Maksud, M. A., Khan, S., Lutfa, L. N., & Quraishi, S. B. (2017). Dietary intake of heavy metals from eight highly consumed species of cultured fish and possible human health risk implications in Bangladesh. *Toxicology reports*, *4*(NA), 574-579. https://doi.org/10.1016/j.toxrep.2017.10.002

World Health Organization. (2006). *Five Keys To Safer Food Manual*.