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Assessment of the bacteriological contamination of selected street foods in open and closed environments in the city of Lucknow

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Abstract

In developing countries, the urban population's association with street food is significant. Consumers favor street food because of its convenience, affordability, and palatability. Nevertheless, the majority of street foods are detrimental to health. The present study aimed to assess the bacteriological quality of selected street foods in open and closed environments in the city of Lucknow. This study focused on 6 street food samples and 120 vendors' hygiene practices. The 6 food samples were selected from open-air stalls, and the same 6 food samples were selected from indoor shops that were randomly selected from 4 different locations in the city of Lucknow. The results of this study revealed that the samples collected from the open-air stalls were contaminated with pathogenic bacteria ranging from 9.44±0.96 log10 to 6.11±1.06 log10 ($p<0.05$). According to the questionnaire results, 81% of respondents were unaware of dish towels, hand washing, cutting nails, covering heads, and using gloves, and 94% of vendors were unaware of practices of knife and cutting board contamination. The findings of this study indicate that the street foods from the indoor shops were served under hygienic conditions, whereas the foods from the open-air stalls were served under unhygienic conditions that were not good for human health. However, in order to improve the final quality of these street foods, further strategies are needed, such as the street food makers' training, with the aim of applying good hygienic practices during production.

Key words: street foods, pathogenic bacteria, vendors, GHPs, practices.

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Introduction

Street food refers to food and beverages for immediate human consumption, with or without the need for additional processing and preparation, that are made or sold by vendors along streets and in other public areas. Street food is becoming increasingly popular in developing countries because of its low cost, availability, and convenience for city dwellers (Sabuj *et al.*, 2018). The demand for prepared street foods has significantly increased in large cities, with many urban residents obtaining a sizable portion of their diet from these sources (Adjrah *et al.*, 2013; Tong *et al.*, 2021). The "street food informal sector" is the area of the food industry where food is sold in public areas or on the streets, frequently without official business registration or regulation. Numerous people, especially in developing nations, rely on this industry for their livelihoods because of its adaptability, accessibility, and frequently low entry barriers. For families working in this informal sector, the street food trade offers employment and a sizable income (Samuel, 2012). Some benefits of street food include being a convenient and affordable source of food, boosting local economies, and offering a distinctive cultural experience. In a local market, for instance, a vendor selling samosa, panipuri, momos (dumplings) offers a quick, inexpensive, and delicious dinner in addition to helping the vendor make a living, important questions remain regarding the safety of such foods. Food poisoning outbreaks associated with street food continue to pose a threat in almost all developing regions, with microbial contamination and adherence to food hygiene and safety rules representing major issues (Derbew *et al.*, 2013; Gadi *et al*., 2018).

Foodborne diseases linked to the consumption of street foods have been reported in numerous areas in India and elsewhere (Das *et al.*, 2012). According to a scientific assessment, 37 outbreaks of foodborne diseases affecting 3455 people have occurred in India over the past 29 years. In one study performed in Hyderabad, 10 outbreaks involving 996 people were documented. Nine cases involved food poisoning caused by *Staphylococcus aureus*, whereas one was caused by *Salmonella* (Kohli *et al.*, 2015). Pani puri and other street foods are frequently linked to various foodborne illnesses. The toxin-producing pathogens present at different levels in these street foods are *Escherichia coli, Salmonella enterica, S. aureus,* other *coliforms, yeasts*, and *molds* (*i.e.*, Shiga toxins, mycotoxins, such as aflatoxins). In addition, *Pseudomonas, Clostridium*, and *Klebsiella* species can cause food poisoning. These bacteria contaminate food and produce toxins that lead to illness when ingested. These are all genera of pathogenic bacteria, which means they have the ability to cause illness. One prominent opportunistic bacterium that causes infections acquired in hospitals is *Pseudomonas aeruginosa*. Serious diseases, including botulism and tetanus, are caused by species of *Clostridium*. One of the main causes of pneumonia, bloodstream infections, and urinary tract

infections is the *Klebsiella pneumoniae* bacteria, which is also becoming more resistant to antibiotics. These microbes cause watery diarrhea, which is frequently accompanied by fever, vomiting, and abdominal cramps in younger children, muscle weakness, and paralysis. Most diarrheal illnesses are caused by coliform bacteria, specifically *E. coli, S. enterica, Shigella*, and *Pathovars*, but very few studies on food contamination with pathogenic microbes have been conducted (Sharma *et al.*, 2014; Kharel *et al.*, 2016; Djibrine *et al.*, 2018; Verma, Firdaus *et al.*, 2023). According to analyses of student snacks, 45% of the foods tested contained artificial food toxins in excess of the safe limit, as well as bacterial contamination (*i.e.*, *E. coli* and *Listeria monocytogenes*) (Dewayani *et al.*, 2018). Pathogens can be carried by vendors and eventually passed on to consumers (Madueke *et al.*, 2014).

Street foods are often susceptible to cross-contamination from different sources, including utensils, knives, flies, rodents, and insects, unsanitary conditions, infrastructure, the location unhygienic open environment, and limited knowledge and training on food safety practices among vendors can lead to unsafe handling and preparation methods (Tambekar *et al*., 2011; Eromo *et al*., 2016; Nemo *et al*., 2017; Ferrari *et al*., 2020). The bacteriological conditions of food have been shown to be influenced by many factors, including raw material quality, food handling and processing, microbes that survive preservation and storage procedures, and post-process contamination, lack of regular inspections and monitoring (Seaman *et al*., 2010; Upadhyaya *et al*., 2017). For safe street food preparation and cooking, knowledge of microbiological risks and their solutions, critical points, practical control, and handling measures, effective supervision, and the fundamentals of food bacteriology and food hygiene must be integrated (Khairuzzaman *et al.*, 2014). The microbial conditions of bacteria isolated from prepared foods sold by street vendors constitute a step toward ensuring consumer safety (Tomar *et al.*, 2018; Verma, Patel *et al.*, 2023). This study was performed to evaluate the microbial conditions of selected street foods in open and closed environments in the city of Lucknow, with a special emphasis on of vendor's food hygiene practices.

Materials and Methods

Study area, design, and sampling procedure

This study was conducted on the street food vending sites of Lucknow city in Uttar Pradesh. Since it is the capital city of the state, Lucknow city has many street food vendors operating on busy streets (markets), near school offices, and in other public places. The 4 survey areas were carefully chosen to reflect the entire city and were the most crowded areas. The 4 sampling sites were selected *via* a selective sampling design and environmental variables, an open-air environment (open-air food stalls) at Charbahg, Aminabad, and Kaiserbagh, and a closed environment (indoor food shops) at LuLu Mall.

Data collection tools and procedures

A food hygiene checklist and direct observation were employed as data collection tools. Content of the questionnaire included issues addressing sociodemographic characteristics, and personnel hygiene, food handling practices, food safety knowledge of the vendors, and access to hygienic water supply and other sanitary facilities.

Sampling and sample collection

A total of 120 vendors were randomly sampled, 30 food vendors were selected from each of the 4 sampling sites, and included in the study, with the food safety and hygiene practices evaluated using a food hygiene questionnaire. The snowballing sampling technique was used to locate all the vendors. The 12 cooked food samples were collected from the most commonly sold foods each day, subjected to microbial analysis (Eromo *et al*., 2016).

These 4 sites were selected to assess and compare the food quality and microbial contamination load from food prepared in different environments. The first ready-to-eat food samples (boiled spicy chickpeas, samosas, chow mein, pani puri, dumplings, and burgers) were randomly collected from the open-air food stalls, and the second samples (boiled spicy chickpeas, samosas, chow mein, pani puri, dumplings, and burgers) were collected from the indoor food shops. Food samples were collected twice from an open-air food stall or an indoor food shop at 1-month intervals. A total of 6 street food samples were collected from various locations in Lucknow city between October and November from both environments (Table 1). The samples were collected in presterilized poly bags, stored at 4°C, and transported to the laboratory for analysis within an hour of collection. A total of 6 food samples were selected from open-air stalls, and 6 food samples were selected from indoor shops. The first 6 food samples were as follows: i) boiled spicy chickpea from the Charbagh market (open stalls); ii) samosa from the Charbagh market (open stalls); iii) chow mein from the Charbagh market (open stalls); iv) spicy pani puri water from the Charbagh market (open stalls); v) dumplings from the Aminabad market (open stalls); vi) burger from the Kaiserbagh market (open stalls). The second set of 6 food samples was as follows: i) boiled spicy chickpea from the LuLu Mall (indoor shops); ii) samosa from the LuLu Mall (indoor shops); iii) chow mein from the LuLu Mall (indoor shops); iv) spicy pani puri water from the LuLu Mall (indoor shops); v) dumplings from the LuLu Mall (indoor shops); vi) burger from the LuLu Mall (indoor shops).

Checklist for food handling practices

Food hygiene practices of all the vendors in the streets were a combination of questionnaires used in a previous study by Tuglo *et al*. (2021), with a few minor changes. The demographic data included experience, sex, educational level, and age. The hygienic practices were evaluated using "Yes" or "No" which were then expressed in proportions. The technique for selecting participants for this section of the survey was the same as that used to identify vendors for the food hygiene and attitude questionnaire.

Microbial analysis and pH measurements

The pH value of street food samples was monitored electrometrically using a digital pH meter CL-54 (Toshcon Industries Pvt. Ltd., Ajmer, India).

Isolation and preliminary screening of bacteria

Nutrient agar media was used for bacterial isolation. Bacteria from the food samples were isolated using the serial dilution method. Plating was conducted under laminar flow to preserve aseptic conditions. To isolate bacteria, 0.1 mL of dilution from each tube was aseptically pipetted and inoculated onto different nutritional agar medium plates *via* the spread plate technique. Luria-Bertani agar (Table 2) was used, and this agar was used for routine cultivation and estimation of not particularly fastidious microorganisms. The isolated colonies were subsequently streaked onto freshly prepared nutrient agar plates and cultured at 32°C for 24 to 48 hours. All plates were inverted and maintained in an incubator at 32°C for 24 to 48 hours. The colonies were routinely trans-

ferred to a new medium and preserved for future use. The culture on the plates was used to determine the colony-forming units (CFU) per gram of food for bacterial quantification. Following the incubation of the plates at 32°C for 24-48 hours, viable bacterial colonies were enumerated and isolated. After the incubation period, plates with 25-90 colonies were selected and enumerated using a colony counter. The microbial counts were converted to log CFU. All isolates were morphologically described using colony morphology and gram staining. The morphological characterization of each isolated colony was conducted by examining its shape, color, texture, and appearance. The texture of a microbial colony was determined by its consistency, which was described as smooth, rough, granular, dull, shiny, or wrinkled. To check texture, the colony is frequently brushed or scraped with a sterile loop to see how it adheres or separates. Friable, stiff, butyrous, and mucoid are common descriptive terms.

Identification of isolated bacterial strains and phylogenetic analysis

The bacterial strains were inoculated in nutrient broth at 30°C in a shaker at 220 rpm for genomic DNA isolation. Following 24 hours of incubation, each culture underwent centrifugation for 10 minutes at 4000 rpm at room temperature. The supernatant was removed, and the cell pellet was employed for genomic DNA extraction using the Bacterial Genomic DNA Isolation Kit (HiMedia). The isolated bacteria were characterized by 16S ribosomal RNA (rRNA) gene sequencing. The 16S rRNA genes were amplified from genomic DNA using the primers P027F and 1378R, targeting a sequence of ~1500 bp. The PCR reaction (25 µL) comprised 1 mL of template DNA, 0.2 µL of each primer (UNI-16-GT-F [AGAGTTTGATCCTGGCTCAG] and UNI-16-GT-R [GGTTACCTTGTTACGACTT]), 200 µL of each dNTP, 10×buffer, 2 mM $MgSO_4$, and 1unit of High-Fidelity KOD Taq DNA Polymerase. The cycle parameters included 4 min of initial denaturation at 94°C and30 cycles consisting of 30 s of denaturation at 94°C, 1 min of annealing at 63°C, and 1 min of extension at 68°C, followed by a final extension of 7 min at 68°C. The PCR product was purified using the PCR Purification Kit (Norgen Biotek, Canada), and sequencing was conducted by CytoGene Research & Development. National Center for Biotechnology Information (NCBI) BLAST (www.ncbi.nlm.nih.gov/BLAST) was utilized to compare the sequences with homologous bacterial 16S rRNA sequences. The discovered sequences were aligned with CLUSTAL W, and a phylogenetic tree was constructed using MEGA 11 software employing the maximum likelihood algorithm.

Statistical analysis

The statistical analysis of the microbial counts conducted on the street food samples during 1-month intervals of investigation is

Table 1. Characterization of the street foods analyzed.

Environments	Street foods	Ingredients	Nature of food
Open/closed environment	Boiled spicy chickpea	Water, salt, chickpeas, potato, onion, spices, oil	Cooked: snack
Open/closed environment	Samosa	Flour, potato, onion, spices, oil, salt	Deep-fried: snack
Open/closed environment	Chow-mein	Flour, different types of vegetables, onion, salt, oil	Shallow fried: snack/staple
Open/closed environment	Spicy panipuri water	Flour, potato, tamarind, salt, and spices	Deep-fried, cooked, and raw ingredients: snack
Open/closed environment	Dumplings	Flour, cabbage, onion, spices, and salt	Steamed: staple
Open/closed environment	Burger	Bread, potato, vegetable, chilli, spices, oil, salt	Shallow fried, and raw ingredients: snack

Table 2. Details regarding chemicals and of the laboratory reagents and tools employed.

S. No.	Laboratory reagents/chemicals/tools description
1.	Luria-Bertani agar (HIMEDIA)
2,	Agar Powder (HIMEDIA)
3.	Ethanol Absolute (Changshu Hongsheng Fine Chemical Co., Ltd.)
4.	Hot air oven (capable of 180ºC)
5.	pH meter
6.	Weighing Balance with least count 0.01 g
7.	Autoclave (capable of 15 psi/121ºC) of suitable size as per need
8.	Laminar air flow chamber with U.V. tube light
9.	Hot plate for media preparation
10.	Inoculation loop/needle
11.	Bunsen burner with liquefied petroleum gas cylinder
12.	Air conditioner
13.	Refrigerator
14.	Colony counting equipment
15.	General glasswares including, petri dishes (made of glass), pipettes (of capacity 1 mL and 10 mL), flasks, test tubes, culture bottles, glass rod, measuring cylinders
16.	Thermometer with least count 1°C
17.	Cotton

reported in Table 2. The survey data and the microbiological count were both analyzed in IBM SPSS version 20 (Armonk, NY, USA). The frequencies and percentages, descriptive data including standard deviation, mean, and lowest and highest scores for food practices were obtained. The microbial counts were converted to log CFU. The analysis of variance test was used to assess significant differences in microbial counts, and statistically distinct means were separated using Tukey's Honestly Significant Difference test. Statistical significance was tested at $p<0.05$.

Results and Discussion

The majority of the street-food vendors examined during the present study either had a low level of education or were illiterate, had less experience, and were not familiar with the subject of food hygiene, which had a large impact on their inadequate safety practices. Most of the respondents (Table 3) (80%) did not cover their hair, mouth, hands, and jewelry when handling, preparing, and serving food. Most of the respondents (84%) did not wash their hands in clean water each time before handling, preparing, and serving food. Most of the respondents (75%) had nails kept short. Animals or pests (flies, dust, *etc*.) were evident (73%), mostly around the vending stall. Only a few respondents (40%) cleaned dirty utensils with soap and water. Adequate wastewater and food disposal facilities were not available for food handlers (69%). Almost all respondents (94%) did not know that knives and cutting boards should be properly sanitized to prevent cross-contamination. Most of the respondents (81%) were not aware that dish towels can be a source of food contamination.

Microbiological counts and pH values of selected street foods

The samples exhibited a pH range of 5.03-6.04 at a temperature of 34°C. The CFU/g metric was employed to quantify bacterial counts in the food samples. In contrast to the samples from indoor shops (Table 4), the samples from open stalls exhibited elevated colony counts (Table 4), signifying a higher degree of contamination in the latter.

Morphological identification and gram staining of isolates

Standard techniques were used to identify various bacterial colonies. For each of the isolated colonies, the shape, color, tex-

Table 3. Food handling and hygiene practices of the street food vendors (n=120).

Food handling and hygiene practices	Yes (%)	No (%)
Water sources are available near your vending area.	41	59
The operators wash their hands in clean water each time before the handling, preparation and serving of food.	16	84
The hair, mouth, hands and jewelry of the operator covered when handling, preparing and serving food	20	80
Vendor having clean clothing	26	74
Vendors nails kept short	25	75
Animals or pests (flies, dust etc.) evident around the vending stall	73	27
Dirty utensils cleaned with soap and water	40	60
Utensils used by the vendor are covered	38	62
Hands washed between handling money and handling or serving food again	12	88
Adequate wastewater and food disposal facilities available	31	69
Knives and cutting boards should be properly sanitized	06	94
Dish towels can be a source of food contamination	19	81

Table 4. Microbial counts (log_{10} CFU/g) of organisms isolated from food samples in open and closed environments.

Sample from open stalls	Pathogenic bacteria	Microbial counts
Boiled spicy chickpea	*Staphylococcus aureus*	7.77±1.35[a]
Samosa	*Campylobacter lanienae*	8.88±0.91[a]
Chow mein	*Priestia megaterium*	7.22±1.55[a]
Spicy pani puri water	*Klebsiella* sp,	9.44±0.96[a]
Dumplings	*Staphylococcus aureus*	6.11±1.06[c]
Burger	*Klebsiella* sp.	6.66±1.26[d]
Sample from indoor shops	**Nonpathogenic bacteria**	**Microbial counts**
Boiled spicy chickpea	*Lactobacillus acidophilus*	2.33±1.92[b]
Samosa	*Brevibacterium linens*	2.22±1.88[b]
Chow mein	*Staphylococcus epidermidis*	2.12±1.48[b]
Spicy pani puri water	*Escherichia coli*	2.77±1.98[c]
Dumplings	*Staphylococcus epidermidis*	2.19±1.56[b]
Burger	*Escherichia coli*	2.68±1.93[c]

Values with various superscripts are significantly different at $p<0.05$.

ture, and appearance were examined as morphological characteristics. The presence of gram-positive or gram-negative lipopolysaccharides was determined. The street food samples contained high concentrations of gram-positive cocci (*Supplementary Figures 1, 2, 4, 5, and 6*) and gram-negative rod strains (*Supplementary Figures 3, 7, and 8*). Following the culture and cellular morphology examinations that facilitated the differentiation of the isolates, multiple gram staining and physiological tests were conducted to identify the microorganisms.

Purified isolated rhizosphere bacterial strains were identified using 16S rRNA sequencing. Bacteria were identified from the boiled spicy chickpea and dumpling samples obtained from an open stall in Charbagh and Aminabad (OP968953), as well as from a boiled spicy chickpea sample collected from an indoor shop in LuLu Mall (OP975666). 16S rRNA sequencing results for the isolated strains RVCP2 and RVCPL1 indicated that their nearest phylogenetic relatives were *S. aureus* (*Supplementary Figure 1*) and *L. acidophilus* (*Supplementary Figure 2*). A samosa specimen was obtained from an open stand in Charbagh (OP968941), while another samosa specimen was procured from an indoor establishment at LuLu Mall (OP975665). The 16S rRNA sequencing data of the isolated isolates RVS2 and RVS3 indicated that their nearest relatives were *C. lanienae* (*Supplementary Figure 3*) and *B. linens* (*Supplementary Figure 4*). A chow mein sample was obtained from an open stall in Charbagh (OP968947), while another chow mein and a dumplings sample were procured from an indoor shop in LuLu Mall (OP975667). 16S rRNA sequencing data for the isolated bacteria RVC2 and RVCL1 indicated that their nearest relatives were *P. megaterium* (*Supplementary Figure 5*) and *S. epidermidis* (*Supplementary Figure 6*). Samples of spicy panipuri and burgers were obtained from an open stall in Charbagh and Kaiserbagh (OP968946), as well as from an interior shop in LuLu Mall (OP975787). 16S rRNA sequencing data for the isolated bacterial strains RVK1 and RVL1 indicated that their nearest relatives were *Klebsiella* sp. (*Supplementary Figure 7*) and *E. coli* (*Supplementary Figure 8*). The nucleotide sequences of these microorganisms were submitted to the NCBI database. A phylogenetic tree was constructed using software (Koichiro Tamura, Tokyo, Japan), depicting the relationships among the bacterial taxa (Figure 1) and the most closely related genera inferred from 16S rRNA gene sequences.

Overall, the results indicated that the colony count was greater in the samples from the open-air food stalls than in those from the indoor food shops. The microbial results are summarized in Table 4. The food samples from the open-air stalls had the greatest degree of contamination (ranging from 9.44±0.96 $\log_{10}$ to 6.11±1.06 $\log_{10}$) with the 6 tested microorganisms ($p<0.05$). The presence of such high microbial counts can be attributed to improper handling of street foods prepared in very dirty surroundings with inadequate storage conditions and wastewater and garbage disposal nearby, providing nutrients and a breeding ground for rodents and other pests that could contaminate food. All samples were contaminated with a variety of pathogenic bacteria, and the microbial counts were highest in the pani puri samples (9.44±0.96 $\log_{10}$ CFU/g), compared to other tested food samples, indicating that most of these samples are potential risks to public health. However, there was no significant ($p<0.05$) difference in the microbial counts of the samples. The high microbial counts relative to the regulatory level (10 CFU/g) in these samples are attributable to the fact that improper food handling practices, such as handling food with bare hands, reusing surfaces without cleaning first, and not wearing aprons, contributed to the presence of these foodborne pathogens. *S. aureus* is conveyed to food by the person handling it. Individuals with skin, nose, or throat infections or inflammatory wounds pass this microorganism through food. The primary regulatory body for food safety in India is the Food Safety and Standards Authority of India (FSSAI). Established under the Food Safety and Standards Act, 2006, FSSAI is responsible for setting science-based standards for food articles and regulating their manufacture, storage, distribution, sale, and import to ensure safe and wholesome food. This Act consolidated various pre-existing food-related laws and aims to create a single point of reference for all food safety matters (Das *et al*., 2010; Tambekar *et al.*, 2011; Eromo *et al.*, 2016; Upadhyaya *et al.*, 2017; Dewayani *et al.*, 2018; Birgen *et al.*, 2020). In the present study, both pathogenic and nonpathogenic microbes were present in the samples examined. Nonpathogenic microbes (ranging from 2.77±1.98 $\log_{10}$ CFU/g to 2.12±1.48 $\log_{10}$ CFU/g), such as *L. acidophilus, B. linens, S. epidermidis,* and *E. coli*, were present in the crowded, closed environment, causing a variety of foodborne illnesses. The street foods boiled spicy chickpeas, pani puri, samosa, chow mein, dumplings, and burger samples were contaminated with a variety of nonpathogenic bacteria, and the microbial counts were highest in the pani puri, and burger samples (2.77±1.98 $\log_{10}$ CFU/g and 2.68±1.93 $\log_{10}$ CFU/g, respectively). However, there was no significant ($p<0.05$) difference in the microbial counts of the boiled spicy chickpeas, samosa, chow mein, and dumplings samples. The water used to prepare street food frequently comes from untreated sources, which increases the bacterial count (Bahir *et al.*, 2022; Alelign *et al.*, 2023). The consumers of street food may be at serious risk if the vegetables used to make samosas, chow mein, dumplings, burgers, and other dishes are not thoroughly cleaned with clean water. Poor hand washing practices by food workers and a lack of proper manufacturing procedures may be causes of *E. coli* contamination. Handling practices contribute significantly to *S. aureus* contamination. The difference in microbial contamination levels between indoor shop and outdoor shop environments is primarily due to variations in source availability, environmental conditions, and human activity. Outdoor air, while containing a diverse range of microorganisms, experiences greater dilution and dispersal. Indoor environments, however, can experience higher concentrations of specific microbes due to factors like human

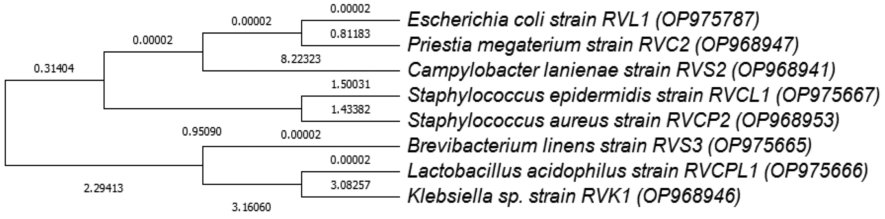

Figure 1. Phylogenetic tree illustrating the relationships among bacterial species.

occupancy, moisture, and limited air circulation.

Food hygiene regulations and legislation

Street foods are regulated by a variety of food laws and regulations. The rules or bylaws governing the activities of street food vendors are a component of a wider body of legislation addressing food, health, or environmental sanitation, where street food activities are subject to legal regulation. Other types of regulation that are in place include licensing or registration systems, inspection systems, and codes of practice. The government has created a variety of laws governing the preparation and distribution of safe street food. The Pure Food Ordinance 1959 (updated 2005) contains various provisions that address the safety of street food, including those that prohibit adulteration of food, the sale of unwholesome food, the sale of exposed foods, and the use of insecticides, as well as violations of the health code and unclean premises. The Consumers Rights Preservation Act of 2009, Sections 272-276 of the Penal Code of 1860, and the Standards and Testing Institution Ordinance 37 of 1985 are additional pertinent legislative provisions pertaining to safe street foods. In recent years, numerous civil society organizations have emerged to promote safe street food and food safety in general. For instance, the Consumers Association, Voluntary Consumers Training & Awareness Society (consumer) has organized awareness campaigns including rallies, seminars, workshops, and policy advocacy. It has also undertaken street food surveys. The public is also made aware of safe street foods through print and electronic media.

Conclusions

The findings of this study revealed that the food samples collected from an indoor shop in a mall were contaminated with non-pathogenic bacteria, reflecting the relatively hygienic nature of the food, which could be consumed without any health problems. The samples collected from the open stall were contaminated with pathogenic bacteria, indicating the unhygienic nature of the food, which could lead to health problems. This study unequivocally demonstrates that almost all the popular foods sold on the streets of the city of Lucknow do not meet the standards for acceptable quality and safety. In this study, the low level of knowledge and poor practices adopted by food operators and the high load of bacteria isolated from most of the street foods studied indicate that food can easily be contaminated due to poor practices adopted by vendors during food handling. It is necessary to take precautions to guarantee that the food items used by street vendors are manufactured and stored in a hygienic manner at the proper temperatures and effectively shielded from flies, dust, wind, and other potential sources of contamination. Washing utensils with soap and hot, clean water is recommended. This study suggests that street food vendors can increase their knowledge and good hygiene practices, food security, and microbial protection through regular interactive training. The consumer safety, business environment, and the livelihoods of vendors and their families should all improve as a result of workable training. In addition to awareness and training programs, supportive measures such as financial aid and constant monitoring are required to improve food safety practices and vendor personal hygiene.

Recommendations

The personal protective equipment (gloves, masks, head caps, *etc*.) of all street food vendors should be regularly checked, and awareness should be increased through educational training programs.

The personal hygiene of street food vendors should be monitored strictly to protect the community.

All street food vendors must be required to wear proper uniforms while cooking and handling food.

All street food vendors must have a health certificate and be free of foodborne diseases.

Food hygiene education should be provided *via* community awareness and training programs.

Street food vendors should clean utensils with clean, hot water and soap.

Street food vendors must maintain clean and hygienic utensils and surroundings.

Hand washing with soap and sufficient water should be performed before eating, while cooking, when handling food, and after using the toilet.

Street foods should be properly covered and protected against dust, flies, *etc*.

Knives, cutting boards, and dish towels should be regularly cleaned.

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Online supplementary material:

Supplementary Figure 1. Bacteria were isolated from cooked spicy chickpea, dumplings samples collected from open-air stalls in Charbagh, Aminabad. The 16S rRNA sequencing data for the isolated strain RVCP2 revealed that it was most closely related to *Staphylococcus aureus.*

Supplementary Figure 2. Bacteria were isolated from cooked spicy chickpea samples collected from indoor shops in LuLu Mall. The 16S rRNA sequencing data for the isolated strain RVCPL1 revealed that it was most closely related to *Lactobacillus acidophilus.*

Supplementary Figure 3. Bacteria were isolated from samosa samples collected from open-air stalls in Charbagh. The 16S rRNA sequencing data for the isolated strain RVS2 revealed that it was most closely related to *Campylobacter lanienae.*

Supplementary Figure 4. Bacteria were isolated from samosa samples collected from indoor shops in LuLu Mall. The 16S rRNA sequencing data for the isolated strain RVS3 revealed that it was most closely related to *Brevibacterium linens.*

Supplementary Figure 5. Bacteria were isolated from chowmein samples collected from open-air stalls in Charbagh. The 16S rRNA sequencing data for the isolated strain RVC2 revealed that it was most closely related to *Priestia megaterium.*

Supplementary Figure 6. Bacteria were isolated from chowmein, dumplings samples collected from indoor shops in LuLu Mall. The 16S rRNA sequencing data for the isolated strain RVCL1 revealed that it was most closely related to *Staphylococcus epidermidis.*

Supplementary Figure 7. Bacteria were isolated from spicy panipuri, burger samples collected from open-air stalls in Charbagh, Kaiserbagh. The 16S rRNA sequencing data for the isolated strain RVK1 revealed that it was most closely related to *Klebsiella* sp.

Supplementary Figure 8. Bacteria were isolated from spicy panipuri, burger samples collected from indoor shops in LuLu Mall. The 16S rRNA sequencing data for the isolated strain RVL1 revealed that it was most closely related to *Escherichia coli.*

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Ethics approval and consent to participate: ethics approval is not applicable for this study because we have only taken the respondent's opinion and did not collect any clinical samples. The consent committee constituted has confirmed that no ethical approval is required. This study follows the guidelines set forth by the General Public Health Law.

Informed consent: informed consent was obtained from all the respondents included in this research.

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