



Determination of Microbial and Heavy Metal Contamination of Popular Street Vended Foods in Faisalabad, Pakistan

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Abstract	Article History
<p>Background: In developing countries, street vended foods continue to expand as an affordable food source which impacts the economy. However, the contamination of these foods leads to the outbreak of foodborne diseases and is considered a significant public health issue in Asian countries. This study assessed the microbial load and heavy metal contents in locally available street foods (shawarma, fruit chaat, and dahi baray) in different locations in Faisalabad city, Punjab province of Pakistan.</p> <p>Methods: A total of 60 food samples from five different locations in Faisalabad city were analyzed for microbial quality (<i>Escherichia coli</i>, <i>Salmonella</i> sp, and <i>Staphylococcus aureus</i>, and total viable count) and heavy metals levels (Zn, Cu, Pb, and Cd). A design was used to conduct questionnaires concerning vendors' knowledge about food hygiene and sanitary practices. Data obtained were statistically analyzed by using the SPSS 21 Statistical Software.</p> <p>Results: The street foods were highly contaminated with <i>Staphylococcus aureus</i> (1.266×10^4 cfu g⁻¹), <i>Escherichia coli</i> (0.370×10^4 cfu g⁻¹), and <i>Salmonella</i> species (0.016×10^4 cfu g⁻¹). The average heavy metal contamination of lead, zinc, copper, and cadmium were measured at 0.955 mg/kg, 3.712 mg/kg, 0.317 mg/kg, and 1.000 mg/kg, respectively. The survey questionnaire indicated the contamination of water and unhygienic conditions as significant sources of low-quality street foods.</p> <p>Conclusions: The results revealed that mostly the street foods sold in Faisalabad were contaminated with heavy metals and pathogenic bacteria. The unhygienic practices and contaminated water were the main factors for unhealthy street vended foods production. In this regard, food-safety practices, education, and regulations related to safe food production have been recognized as measures for ensuring the quality of vendor foods.</p> <p>Keywords: Street vended foods, contamination, microbes, heavy metals, public health</p>	<p>Received: 6 May 2022 Accepted: 13 May 2022 Published: 13 May 2022</p> <div data-bbox="1220 996 1460 1220" style="text-align: center;"> </div> <p style="text-align: center;">Scan QR code to view*</p> <p style="text-align: center;">License: CC BY 4.0*</p> <div data-bbox="1204 1288 1476 1377" style="text-align: center;"> </div> <p style="text-align: center;">Open Access article.</p>
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Introduction

Street vended foods are foods and beverages that are prepared and sold in public places and streets. These foods are available for immediate consumption or can be consumed later without further processing. In urban areas, these foods have an integral role both economically and socially to fulfill the food demands (Djibrine *et al.*, 2018). In developing countries, street vended foods can play an important role in delivering the nutritional components and addressing the dietary needs of Asian masses by providing them inexpensive and easily accessible foods. These ready-to-eat foods are the most efficient source of employment and low-cost business. They are very popular among middle to the low-income household sector and school-going students (Imathlu, 2017). Asian countries like India, Pakistan, China, and Thailand have large numbers of street foods sold by a larger number of vendors (Albuquerque *et al.*, 2020).

Although street vended foods provide many advantages, but it has been reported that these foods cause serious health and safety issues to food handlers and consumers. These issues happen because of the lack of safety knowledge, inappropriate sanitation practices, improper hygienic conditions,

and a big gap in public awareness (Rane, 2011). Preparatory operations are usually performed in unsuitable setups including inadequate storage conditions, improper cookware, contaminated utensils, improper personal hygienic condition, poor sanitation, the use of contaminated ingredients, and cross-contamination (Campos *et al.*, 2015).

The main possible issue with foods sold on streets that can impose health hazards for consumers is their contamination. The contamination of street foods with microbial, chemical, and metallic agents causes a huge disease burden and a major public concern (Razzaq *et al.*, 2014). Food-borne pathogens are the main cause of human illnesses like diarrhea, nausea, and vomiting and in some cases lead to severe fatal disease conditions and death. Major food-borne pathogens associated with health risks are *Escherichia coli*, *Salmonella typhi*, *Pseudomonas*, *coliforms*, *Staphylococcus aureus*, *streptococcus*, and *Proteus species* (Nobili *et al.*, 2017).

Due to the natural sources and pollution, heavy metals exist everywhere in the environment which results in unintentional exposure of humans to heavy metals (Haque *et al.*, 2019; Orajiaka-Uchegbu *et al.*, 2020). The air, water,

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soil, and industrial pollution are the main sources of heavy metals dispersion in the environment and result in food contamination (Ifemeje *et al.*, 2016). Human exposure to toxic heavy metals is responsible for many human health problems such as kidney dysfunctions, osteomalacia, osteoporosis, heart diseases, and most forms of cancer (Chung *et al.*, 2013; Patrick-Iwuanyanwu *et al.*, 2020).

In Pakistan, the majority of people are consuming street vendor foods and intake of these foods has an important socio-economic and dietary role with associated risk factors. Street vended foods are increasingly consumed in educational institutions, markets, auto stations, and industrial areas in mainly developing countries without the safety of these foods being guaranteed. Therefore, this study was conducted to analyze the heavy metals and microbial contamination in shawarma, fruit chaat, and dahi baray sold and consumed in Faisalabad city.

Materials and Methods

Procurement of food samples

Food samples were procured from five different locations in Faisalabad city, Punjab province of Pakistan including D- Ground, Satiana Road, Dhobi Ghat, Gulberg, and Samanabad. These locations were selected because travellers stop over to buy foods sold by the roadside. Samples were collected from each location based on their maximum sale rate. The samples including shawarma, fruit chaat, and dahi baray were aseptically collected, put in sterile containers, and preserved at 4°C until analysis. For each food item, 20 samples were collected so in total 60 food samples were collected.

Microbial analysis

First of all, a homogenized sample was prepared by dissolving 10 g of each food sample in distilled water (90 mL). In a test tube, each homogenate sample (1 mL) was mixed with 0.85% sterile saline (9 mL). The sample in a test tube was serially diluted to obtain the dilutions up to 10^{-5} as per the method described previously (Das *et al.*, 2010). To isolate the bacteria, 0.1 mL from each tube of appropriate dilution was inoculated aseptically on Blood agar (for *Salmonella sp.*), Baird parker's agar (for *Staphylococcus aureus*), MacConkey agar (for *Escherichia coli*) and Tryptone glucose yeast extract agar (for the total viable count) using spread plate technique. Further, the plates were incubated for 24 hours at 37°C in aerobic conditions. After that, bacterial enumeration was performed by determining the colony-forming units per gram of food sample.

Heavy metal analysis

The heavy metal contents were determined spectrophotometrically (Model-750-8024 Hitachi, Tokyo Japan) according to the method of Lanre-Iyanda and Adekunle (2012). Briefly, the food samples were oven-dried ($105 \pm 5^\circ\text{C}$) and converted into a fine powder. After that 1 g of dried ground sample was ashed for 12 hours. The ashed sample was digested with HNO_3 (5M) to give a clear solution. The digested sample was filtered in a volumetric flask (50 mL) and deionized water was added to it to make the solution up to the mark. The heavy metals were analyzed by atomic absorption spectrophotometer at the wavelengths (nm) 213.9, 324.7, 283.3, and 228.8 for Zn, Cu, Pb, and Cd, respectively.

Survey and questionnaire

Data related to vendors' knowledge about food hygiene, practices, food safety as well as sanitary conditions of the foodservice establishments were collected through face-to-face interviews using semi-structured questionnaires as well as through observations. The prepared in the English version and translated to Urdu version which is the local language of the study participants.

Statistical analysis

Results obtained were analyzed statistically by interpreting as analysis of variance (ANOVA) using descriptive statistics through the SPSS 21 Statistical Software. The data is represented as means of replicate determinations.

Results and Discussion

Microbial quality

A total of 60 samples of street foods were examined in this study. Among the samples tested, the majority of them revealed pathogenic contamination. Three important pathogens (*E. coli*, *Salmonella*, and *S. aureus*) and total viable count were analyzed in all food samples and significant results of bacterial enumeration have been presented in Table 1. Total viable counts (TVC) of bacteria in all experimental samples varied between 0.343 to 3.226×10^4 cfu g^{-1} , *E. coli* between 0.020 to 0.370×10^4 cfu g^{-1} , *Salmonella spp.* between 0.003 to 0.016×10^4 cfu g^{-1} and *S. aureus* between 0.010 to 1.266×10^4 cfu g^{-1} . Among

different bacterial pathogens isolated in the present study *Staphylococcus aureus* showed the highest count followed by *Escherichia coli* and *Salmonella spp.* The results of this study are well correlated with the previous investigation in which 37 samples of ready-to-eat foods showed bacterial counts ranging from 4.5×10^5 to 1.12×10^6 . The 56 isolates were identified as *Escherichia coli* (37.5%), *Shigella spp.* (19.64%), *Staphylococcus aureus* (14.20%), *Klebsiella sp.* (10.71%), *Enterobacter spp.* (8.93%), *Salmonella spp.* (5.36%) and *Pseudomonas aeruginosa* (3.57%) respectively (Sharma and Mazumdar, 2014). In another study, the detection rate was highest for *Bacillus cereus* (10.0%), followed by *Staphylococcus aureus* (1.3%) and *Salmonella* (0.2%) in sandwiches produced on-site and served in bakeries, cafés, and sandwich bars in South Korea (Jang *et al.*, 2013). The presence of these microbes in the food may be linked to different factors such as improper handling and processing, contaminated rinsing and processing water, cross-contamination, dirty utensils, personal hygiene, and environmental condition (Kabwang *et al.*, 2019).

Heavy metal contents

Trace metals found in food and water can be nutritionally beneficial, or highly toxic depending on the type of metal and its concentration. The study showed the distributions of heavy metals as the results are given in Table 2. The levels of lead are ranged from 0.014 to 0.955 mg/kg, zinc from 0.010 to 3.712 mg/kg, copper from 0.010 to 0.317 mg/kg, and cadmium from 0.001 to 1.000 mg/kg respectively. Multiple metal contaminations of street vendor foods give grounds for concern. According to the World Health Organization, the permissible limits for Pb should be up to 210 $\mu\text{g}/\text{kg}$, for Zn up to 60 mg/60 kg, and for Cu, up to 30 mg/60 kg (FAO-WHO, 1993). According to the Egyptian Organization for Standardization Quality and Control, the recommended limit of Cd should not exceed 0.0067-0.0083 mg/kg (EOSQC, 1993). The food samples with uncovered exposure after cooking had a significantly higher deposit of heavy metals and by-products than the food samples that are covered after cooking. The higher level of heavy metals may be due to the increasing environmental contamination, water pollution, and contaminated fumes and effluents from traffic emissions (Onakpa *et al.*, 2018). In addition, utensils used for cooking may be a source of heavy metals (Ojezele *et al.*, 2016).

Socio-demographic profile of vendors, food hygiene knowledge, and practices

The socio-demographic data of the food vendors are presented in Table 3. The majority of them (50%) were between 31 to 40 years of age. With regards to the educational level, 42% of vendors had secondary education while only 34% had a college education. Food handlers are expected to have knowledge and skills about handling foods hygienically. Only 20% of all food vendors in the study received food hygiene training and 90% acquire knowledge of food preparation through observation. Most vendors (70%) were stationary vendors. It was observed that 60% of the vendors prepared food at the stall. In the case of personal hygiene, the conditions were not proper, only 30% of vendors used aprons, 90% handled foods with bare hands while 10% wore hair covering and 70% opened the polythene bags by blowing air in them. Regarding food storage, 30% of vendors stored the food before serving in an open environment in the stalls while 30% had leftovers for serving the next day, and 64% of vendors washed their utensils with the same water again and again until it become dirty and unclear. In waste disposal, 36% of vendors threw the waste carelessly in the surroundings of their stall which ultimately lead to environmental pollution.

Street vended foods are the main source for the transmission of fatal diseases that could be life-threatening in a long run. Foods could get contaminated before cooking or after cooking through the activities of food handlers. Most food vendors do not have licenses, not got training regarding food safety, personal hygiene, and sanitation practices so mostly work under unsanitary conditions (FAO, 1990). There have been gaps between the practices and knowledge of food handlers. The food handlers did not usually practically implement their knowledge. One reason for vendors to prepare foods in unsanitary conditions is the lack of knowledge, and lack of guidance, and practices about the production of street foods (Faour-Klingbeil *et al.*, 2015). From the food safety point of view, the environment and conditions under which food is prepared are not acceptable. Therefore, efforts should be put into the provision of safe infrastructure including clean portable water and area for waste disposal (Samapundo *et al.*, 2015).

Conclusion

This study concludes a direct relationship between the microbial and metal contamination of street vended foods sold on-site and health risk factors associated with them. The results demonstrate that the most popular types of

Table 1: Range for enumeration of pathogenic bacteria ($\times 10^4$ cfu g^{-1})

Samples	TVC	<i>E. coli</i>	<i>S. aureus</i>	<i>Salmonella</i>
Shawarma (n=20)	1.216 - 3.013	0.063 - 0.250	0.010 - 0.933	0.003 - 0.016
Fruit chaat (n=20)	0.343 - 3.226	0.020 - 0.156	0.013 - 1.013	0.003 - 0.010
Dahi baray (n=20)	0.386 - 3.213	0.043 - 0.370	0.016 - 1.266	0.003 - 0.006

Table 2: Range for the amount of heavy metals contamination (mg/kg)

Samples	Lead	Zinc	Copper	Cadmium
Shawarma (n=20)	0.016 - 0.955	0.161 - 3.712	0.017 - 0.317	0.001 - 1.000
Fruit chaat (n=20)	0.014 - 0.093	0.010 - 0.092	0.012 - 0.089	0.001 - 0.186
Dahi baray (n=20)	0.014 - 0.188	0.012 - 0.042	0.010 - 0.091	0.001 - 0.040

Table 3: Socio-demographic profile of vendors and food hygiene knowledge and practices

Parameter	Frequency n=50 (%)
Age (years)	
21 – 30	15 (30%)
31 – 40	25 (50%)
41 – 50	10 (20%)
Educational Attainment	
None	7 (14%)
Primary	15 (30%)
Secondary	21 (42%)
College	17 (34%)
Type of vendor	
Stationary	35 (70%)
Mobile	15 (30%)
Food hygiene training received	
Yes	10 (20%)
No	40 (80%)
Food vending knowledge acquisition	
Formal Training	5 (10%)
Observation	45 (90%)
Place for food preparation	
At the home	20 (40%)
At the stall	30 (60%)
Food Preparation	
Washing the food before cooking	35 (70%)
Heating the food before serving	40 (80%)
Prepared on the same surfaces more than twice	45 (90%)
Preparation surface	
Clean	30 (60%)
Dirty	20 (40%)
Wash surface before using surface	35 (70%)
Reuse oil for frying	40 (80%)
Personal hygiene	
Using apron	15 (30%)
Food handling with bare hands	45 (90%)
Hair covering	5 (10%)
Blows air into polythene bag before use	35 (70%)
Serving food	
Metal plates	35 (70%)
Plastic plates	20 (40%)
Plastic bags	40 (80%)
Food storage	
Openly in the stalls	15 (30%)
Covered utensils/warmers/coolers	30 (60%)
Leftovers	
Consumed	30 (60%)
Stored for use the next day	15 (30%)
Environment	
Clean	30 (60%)
Dirty	20 (40%)
Water supply	
From home	30 (60%)
From nearby borehole	15 (30%)
Cleaning of utensils	
Water and detergents	10 (20%)
Clean water	18 (36%)
Dirty water	32 (64%)
Waste disposal	
Where?	
Bush	18 (36%)
Waste bin	35 (70%)
When?	
Daily	43 (86%)
Weekly	7 (14%)

street foods sold in Faisalabad city, Punjab province of Pakistan are contaminated, and do not meet safety and quality levels. Some of the isolated bacteria such as *E. coli* and *S. aureus* are potential enteric pathogens. Trace metals (Pb, Zn, Cu, and Cd) were analyzed in the food samples. Mostly, these elements showed exceeded level than the recommended safe level of dietary exposure. Street foods, therefore, pose a health threat and in this regard, food-safety practices, education, and regulations related to food production have been recognized as the measures to ensure the improvement of the quality of street foods.

Competing interests

The authors report no conflicts of interest.

Authors' contributions

Sadia Hassan conceptualized and performed the study. Muhammad Kamran Khan provided technical assistance and guided in the data collection. Muhammad Adil Farooq helped with drafting the manuscript.

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