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Research Article

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Widespread Microbiological and Chemical Hazards in Vizianagaram Street Foods Require Urgent Food Safety Measures

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Abstract

Street foods are an affordable and culturally significant part of diets in India, but they often pose serious safety concerns. This study evaluated the quality of nine commonly consumed street foods in Vizianagaram using microbiological analysis and fourier-transform infrared (FTIR) spectroscopy. Results showed widespread microbial contamination, with high total viable counts (TVC), coliforms, and frequent detection of *Staphylococcus aureus*. Fungal contamination was observed in all samples, indicating unhygienic preparation and storage conditions. FTIR analysis confirmed the presence of acrylamide in every item, significant lipid oxidation in fried foods, and undeclared artificial sweeteners in several products. These findings reveal both acute and chronic public health risks, particularly for vulnerable consumers. The study emphasizes the urgent need for vendor training, stricter monitoring, and the use of rapid detection tools to strengthen food safety. Improving hygienic practices while preserving the socioeconomic role of street food vending is essential for safeguarding public health.

Keywords

Street food, Food safety, Microbiological contamination, Public health

Introduction

Street foods provide affordable meals and employment opportunities in many low- and middle-income countries, including India, where they are a significant part of urban food culture [1, 2]. However, their safety is frequently compromised by inadequate hygiene, unsafe water, and unregulated preparation practices [3-5]. Studies from cities such as Hyderabad and Pune have documented widespread microbial contamination in street foods, yet region-specific data, particularly from smaller cities like Vizianagaram, remain limited [1, 6].

In addition to microbial hazards, chemical contaminants such as acrylamide and lipid oxidation byproducts present significant risks. Acrylamide, formed during high-temperature cooking of starchy foods, has carcinogenic potential [7-9]. Lipid oxidation, common in repeatedly heated oils used by street vendors, reduces nutritional quality and produces harmful compounds [2, 10]. Detection of these hazards is often challenging, as conventional methods like liquid chromatography–tandem mass spectrometry, though accurate, are resource intensive [11].

FTIR spectroscopy has emerged as a rapid and non-destructive alternative for screening food quality and detecting contaminants [12-14]. This study applies a combined approach-standard microbiological methods and FTIR analysis-to assess both microbiological and chemical safety of popular street foods in Vizianagaram. By addressing existing knowledge gaps, it provides critical insights

into local food safety challenges and highlights the need for improved hygiene and monitoring practices.

Materials and Methods

Sample collection and preparation

Nine street foods were collected from high-traffic areas in Vizianagaram, including Panipuri, Pav Bhaji, Samosa, Shawarma, Noodles, Mango Jelly, Boondi Laddu, Rose Milk, and Chaat (Figure 1). Samples were stored in sterile containers and transported under control conditions to prevent contamination [4, 6].

Microbiological analysis

TVC were determined using Plate Count Agar, with incubation at 37 °C for 24 - 48 h [3, 4]. Coliforms were identified via MacConkey Agar and Indole, Methyl Red, Voges-Proskauer, and Citrate tests, while *S. aureus* detection employed Mannitol Salt Agar and coagulase testing [5, 6]. Fungal contamination was assessed using Sabouraud Dextrose Agar [3].

FTIR spectroscopy for chemical analysis

FTIR spectroscopy is widely used in food analysis due to its ability to provide rapid, accurate, and non-destructive detection of a range of chemical constituents and contaminants in various food matrices [12, 15]. FTIR, especially when combined with chemometric approaches, enables effective identification of adulterants, quality markers, and harmful substances in food products [12, 16].

Acrylamide was identified through characteristic FTIR peaks at 1650 cm^{-1} (amide I) and 1550 cm^{-1} (amide II) [13, 14]. Lipid oxidation markers included hydroperoxides (3400 cm^{-1}) and aldehydes (1745 cm^{-1}) [2, 10]. Artificial sweeteners were detected via unique spectral signatures, such as aspartame (1750 cm^{-1}) and saccharin (1180 cm^{-1}) [12, 17].

Results and Discussion

Microbiological contamination

The TVC of the analyzed street foods varied considerably, with the lowest microbial load observed in Samosa (22 colony forming units (CFU)/mL) and the highest in Panipuri (528 CFU/mL) (Figure 2). According to international standards for ready-to-eat foods, microbial loads exceeding 100 CFU/mL are considered unsatisfactory and pose a direct risk of foodborne illness. The high TVC in items such as Panipuri, Shawarma, and Chaat clearly indicates poor hygienic practices during preparation and serving. These findings are consistent with earlier reports from urban Indian markets, where lack of infrastructure, limited water supply, and street-side exposure contribute significantly to microbial proliferation [3, 4].

The presence of coliforms, especially in Panipuri and Samosa, highlights fecal contamination and points towards either the use of contaminated water or improper hand hygiene by vendors (Figure 3). Coliform detection is widely accepted as an indicator of overall sanitary quality, and their occurrence in ready-to-eat foods is a matter of serious concern. This suggests that commonly used water sources, particularly for washing vegetables and preparing chutneys or flavored water, are not microbiologically safe. These findings align with reports from Hyderabad and Pune where similar contamination patterns



Figure 1: Street food samples (n = 9) collected from different vendors in Vizianagaram.

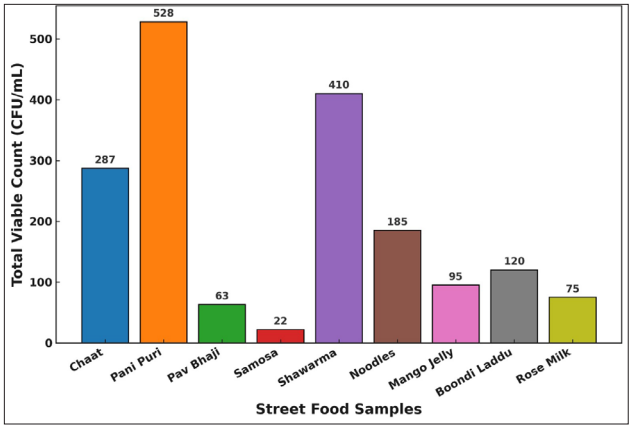

Figure 2: TVC (CFU/mL) of nine street food samples determined by standard plate count method. Pani Puri, Shawarma, and Chaat showed the highest microbial load compared to other foods.

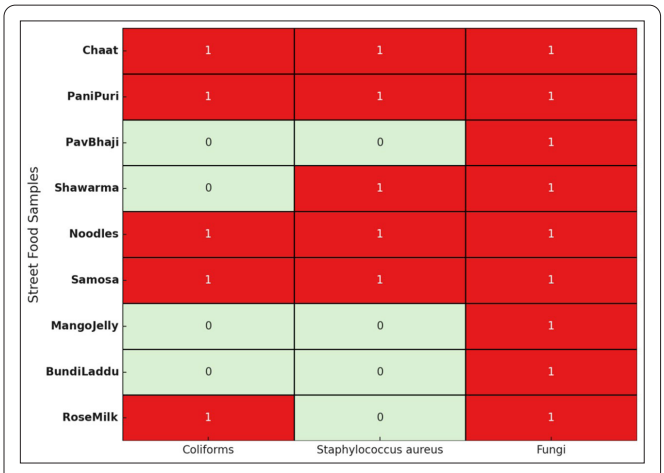

Figure 3: Heatmap showing presence (+) or absence (–) of microbial contaminants in street food samples. Coliforms, *S. aureus*, and fungi were detected in multiple foods, indicating widespread contamination.

were linked to the absence of potable water in street vending locations [1, 6].

The detection of *S. aureus* in 44% of the samples further underscores hygiene failures in handling and storage. Since *S. aureus* is commonly transmitted from food handlers via skin, nasal carriage, or utensils, its prevalence in nearly half of the samples signals inadequate personal hygiene and poor temperature maintenance during storage. The presence of this pathogen is critical, as enterotoxin-producing strains are capable of causing rapid-onset food poisoning even at relatively low bacterial counts. Previous research in Indian metropolitan areas has similarly reported widespread contamination of street foods with *S. aureus*, linking it to insufficient vendor training and poor enforcement of food safety regulations [5, 18].

Fungal contamination was universally present across all nine food items tested (Figure 3). This suggests that exposure to dust, unhygienic preparation surfaces, and environmental spores plays a significant role in food contamination. Foods prepared and served in open-air environments are highly vulnerable because fungal spores are widespread in soil, air, and unwashed raw materials. While some fungi may be harmless, their presence also raises concerns about potential mycotoxin contamination under favorable storage and environmental conditions. This trend mirrors reports from other Indian states where open display and prolonged storage of snacks have been associated with fungal colonization [3].

Taken together, figure 2 and figure 3 highlight the multifaceted microbial risks associated with street foods in Vizianagaram. The combination of high bacterial loads, coliform contamination, and universal fungal presence reflects a breakdown in food safety practices, ranging from water quality and raw material handling to vendor hygiene and environmental exposure. These findings confirm earlier observations from Indian urban settings. They also highlight the urgent need for targeted interventions such as better access to clean water, vendor training in hygienic food preparation, and regular microbial surveillance of high-risk foods.

Chemical hazards

FTIR spectroscopy is widely used in food analysis due to its ability to provide rapid, accurate, and non-destructive detection of a range of chemical constituents and contaminants in various food matrices [12, 15]. FTIR, especially when combined with chemometric approaches, enables effective identification of adulterants, quality markers, and harmful substances in food products [12, 16].

Acrylamide detection

Acrylamide was detected in all food items analyzed (Figure 4). This compound, well known for its carcinogenic potential, is typically formed when starchy foods are subjected to high-temperature cooking such as frying, baking, or roasting [13]. The universal detection of acrylamide in this study strongly suggests that local cooking practices, including deep frying and prolonged heating, contribute substantially to its formation. These findings are consistent with earlier research highlighting the ubiquity of acrylamide in processed and fried street foods [13, 14]. Its presence in every sample underscores the widespread exposure risk to consumers.

Lipid oxidation and reuse of cooking oils

Distinct FTIR peaks associated with lipid oxidation were observed in Panipuri, Samosa, Shawarma, Pav Bhaji,

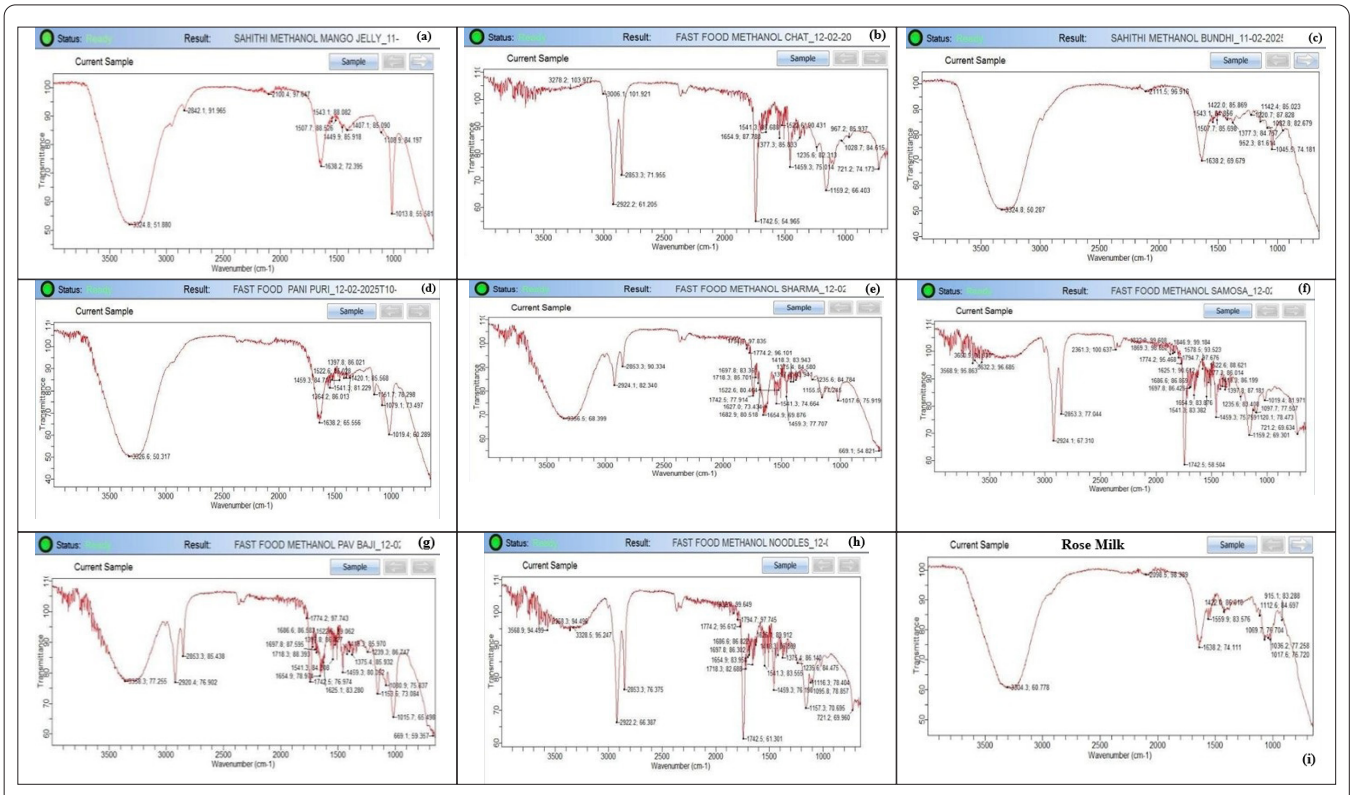

Figure 4: FTIR spectra showing acrylamide detection in all nine food samples. Characteristic peaks at 1650 and 1550 cm^{-1} confirm acrylamide formation during high-temperature cooking.

and Noodles. Oxidized lipids, including hydroperoxides and aldehydes, are formed during repeated or prolonged heating of oils, a common practice among street vendors aiming to reduce costs (Figure 5). Such degradation not only lowers nutritional quality but also produces potentially toxic compounds linked to oxidative stress and chronic diseases. The detection of oxidation markers in multiple fried foods confirms that oil reuse is a routine practice, highlighting a critical gap in safe food preparation [2, 10].

Artificial sweeteners in street foods

FTIR profiling also identified the use of artificial sweeteners in Shawarma, Pav Bhaji, and Chaat. These additives were not disclosed to consumers, thereby violating the labeling and usage norms prescribed by the Food Safety and Standards Authority of India (FSSAI) (Figure 6). While artificial sweeteners may be used to enhance flavor or mask undesirable tastes, their unregulated presence poses both ethical and health-related concerns, particularly for individuals with sensitivities or metabolic conditions [12, 17].

Taken together, the chemical analyses reveal a dual threat: on one hand, the presence of process-induced contaminants such as acrylamide and oxidized lipids; and on the other, the undeclared use of synthetic additives. Both categories represent significant public health risks, calling for urgent interventions in vendor practices, stricter regulatory monitoring, and consumer education.

Consumer behavior and awareness

Consumer practices play a crucial role in food safety outcomes. Many people are drawn to street food because of their affordability, taste, and cultural relevance, often prioritizing convenience over safety. However, limited awareness of microbial and chemical risks means that consumers may overlook unhygienic preparation environments or unsafe handling practices [3, 4]. Studies have shown that consumers rarely question the quality of water used, the reuse of cooking oil, or the presence of undeclared additives, even when these are common practices among vendors [1]. Strengthening public health therefore requires not only improving vendor hygiene but also educating consumers about safe food choices, personal hygiene, and reporting mechanisms. Informed consumer demand can create pressure for safer practices, thereby complementing regulatory oversight and vendor training programs.

Public health implications

The dual burden of microbiological and chemical contaminants poses acute and chronic health risks [19, 20]. Vulnerable groups, including children and immuno-compromised individuals, face heightened susceptibility to gastroenteritis and long-term carcinogenic effects [3, 5]. The pervasive presence of *S. aureus* and coliforms mirrors findings in Pune and Hyderabad, underscoring national food safety challenges [1, 4, 6].

Intervention strategies

Vendor training and infrastructure

Targeted awareness programs were conducted to educate

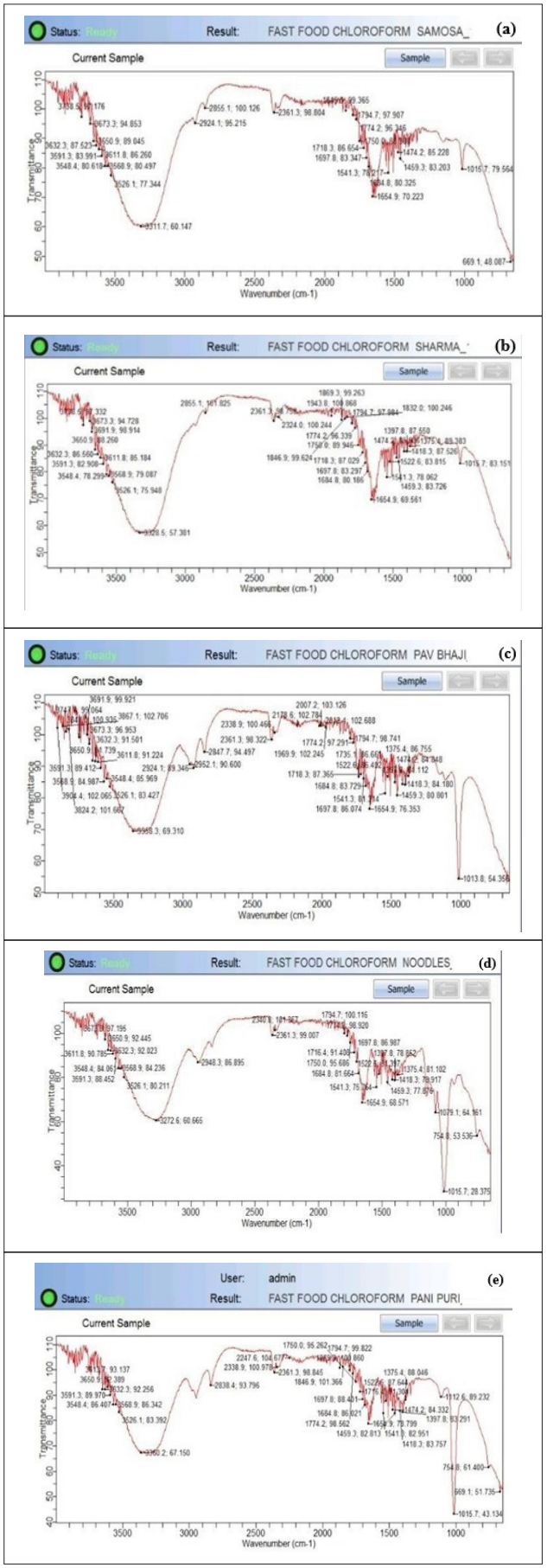

Figure 5: FTIR detection of lipid oxidation markers (hydroperoxides and aldehydes) in selected fried foods, including Pani Puri, Samosa, Shawarma, Pav Bhaji, and Noodles. Peaks observed at 3400 and 1745 cm^{-1}.

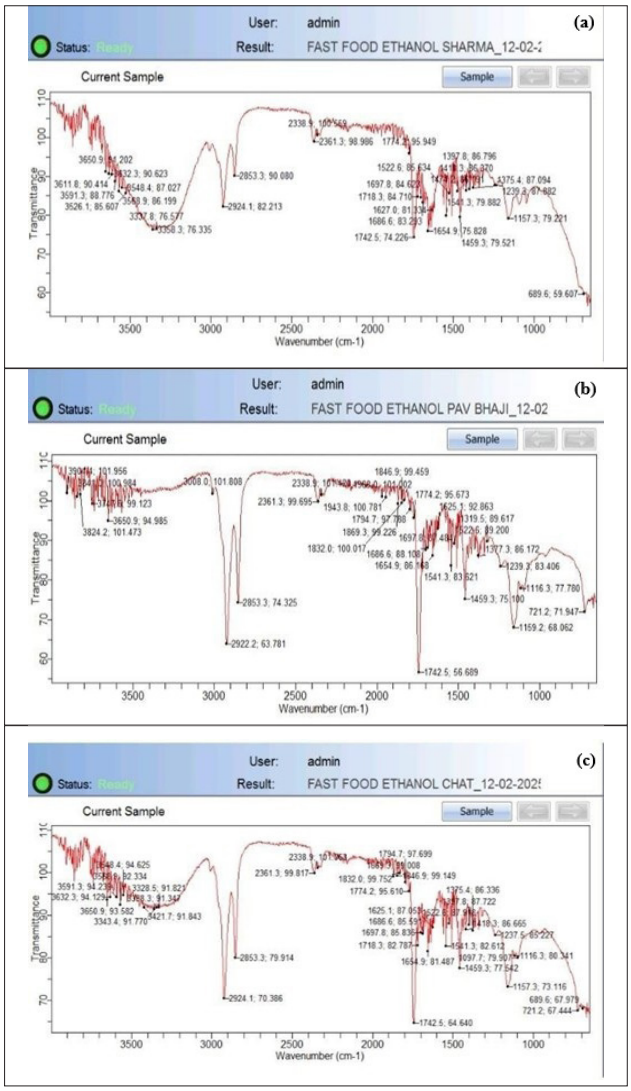

Figure 6: FTIR spectra showing presence of artificial sweeteners in Pav Bhaji, Shawarma, and Chaat, with characteristic peaks at 1750 and 1180 cm^{-1}. Sweeteners were undeclared by vendors.



Figure 7: Awareness program for street food vendors on safe hygiene practices, including hand hygiene, clean water usage, and proper cooking methods.

vendors on hygienic practices, including hand hygiene, safe water usage, and temperature control, using local languages to ensure better compliance [1, 5]. Infrastructure improvements such as access to clean water and affordable refrigeration are also essential for reducing contamination [1, 18] (Figure 7).

Regulatory enforcement and monitoring

Adopting rapid detection tools like FTIR or paper-based sensors [13, 21] could enhance FSSAI's monitoring capacity. Collaborative efforts between regulators and vendor associations can promote compliance without jeopardizing livelihoods [2, 5, 18].

Consumer awareness campaign

Educating consumers on identifying safer vendors and hygienic practices can reduce risk exposure. Social media platforms and community networks offer scalable outreach channels [1, 18].

Emerging technologies for street-level food safety monitoring

Recent advances in analytical technologies are making food safety assessments faster, portable, and more practical for field use. Biosensors have gained significant attention for their ability to detect microbial and chemical contaminants with high sensitivity. Enzyme-based, immunological, and nucleic acid biosensors are being developed to rapidly identify pathogens such as *Escherichia coli* and *S. aureus* directly in food samples. These devices reduce the reliance on laboratory infrastructure and provide results within minutes.

Portable detection kits are also being increasingly applied in food safety surveillance. For example, lateral flow assays and paper-based microfluidic devices allow on-site detection of adulterants, toxins, and spoilage indicators. Combined with smartphone-based imaging and cloud connectivity, these kits can provide low-cost, user-friendly solutions for vendors, inspectors, and even consumers.

In addition, handheld spectroscopic devices, such as portable FTIR and Raman analyzers, are being adapted for street-food testing. These tools can non-destructively screen for chemical hazards like acrylamide or lipid oxidation byproducts. Integration with AI-driven mobile applications

further enhances their capacity for real-time data interpretation and reporting.

Collectively, these emerging technologies hold the potential to transform street-level food monitoring from a reactive process to a proactive system, enabling timely interventions, improving public confidence, and reducing health risks associated with contaminated street foods.

Conclusion

This study reveals systemic food safety failures in Vizianagaram's street food sector, marked by microbiological hazards and chemical contaminants. While the socioeconomic role of street vending necessitates balanced interventions, urgent action is required to mitigate public health risks. Future research should explore socio-economic drivers of unsafe practices and evaluate intervention efficacy. Integrating advanced analytical methods like FTIR into regulatory frameworks offers a pragmatic path toward safer street food ecosystems.

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Conflict of Interest

None.

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