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Comparative Effects of Dietary Exposure to Petrol, Kerosene, and Diesel on Renal Function and Electrolyte Homeostasis in Wistar Rats

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Abstract

Petroleum products are widely used in Nigeria, but repeated exposure may adversely affect renal function and electrolyte balance. This study compared the effects of dietary exposure to petrol, kerosene, and diesel on renal function and electrolyte homeostasis in Wistar rats. Twenty-eight adult male rats were randomly assigned to four groups of seven animals each. The control group received normal feed, while the exposure groups received feed contaminated with kerosene, petrol, or diesel at a concentration of 10 mL/kg feed for 21 days. Serum creatinine, urea, sodium, potassium, chloride, and bicarbonate were measured at the end of the exposure period using standard laboratory

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methods. All three petroleum products altered renal biochemical markers and electrolyte concentrations compared with the control group. Petrol exposure produced the highest serum creatinine, sodium, and potassium concentrations, whereas diesel exposure produced the highest serum urea and chloride concentrations. These findings provide comparative experimental evidence that repeated dietary exposure to petroleum products may impair renal function and disrupt electrolyte homeostasis, with petrol showing the greatest nephrotoxic potential under the conditions studied.

Keywords: Petroleum Products; Dietary Exposure; Nephrotoxicity; Electrolyte Homeostasis; Wistar Rats

INTRODUCTION

Street food vending is a major component of the informal urban economy in Nigeria, providing affordable, convenient meals to students, workers, and low-income earners, and is especially prominent around academic institutions where catering alternatives are limited (Adeosun et al., 2023). Ready-to-eat (RTE) foods sold by these vendors are widely consumed by university students because of their low cost and accessibility, but their safety is frequently compromised by poor handling, inadequate storage, and unsanitary preparation environments (Onohuean et al., 2025).

Consumption of contaminated street food is consistently linked to foodborne illnesses such as diarrhoea, typhoid fever, and gastroenteritis. Pathogenic bacteria including Escherichia coli, Salmonella spp., Staphylococcus aureus, and Bacillus cereus are commonly isolated from RTE foods across Nigerian markets and university communities, and pose a continuing risk to consumers who rely on these foods daily (Onohuean et al., 2025; Makinde et al., 2021). A growing body of evidence also shows that these isolates are frequently resistant to one or more commonly prescribed antibiotics, reflecting the wider crisis of antimicrobial resistance (AMR) that the World Health Organization has identified as one of the most pressing global health threats of the present decade (WHO, 2025; GBD 2021 Antimicrobial Resistance Collaborators, 2024). Because RTE foods sold without regulatory oversight can serve as an under-recognised reservoir and transmission route for resistant strains, characterising the antibiogram of foodborne isolates provides evidence that is directly useful for guiding empirical treatment of foodborne infections and for informing food-safety policy (Tacconelli et al., 2025).

Previous Nigerian studies have repeatedly reported substantial bacterial contamination of street-vended foods, with isolates frequently exhibiting multidrug resistance (Makinde et al., 2021; Oranusi and Braide, 2012). Despite this accumulating evidence, food-safety regulation in Nigeria remains poorly enforced, and most vendors operate without formal training in food hygiene, which increases the likelihood of contamination reaching the consumer (Akinyele et al., 2024).

Street food vending around Federal University Wukari provides an essential service to students, staff, and the surrounding community, but the microbiological quality of the foods sold has not previously been documented. Given the rising global threat of AMR, the absence of local surveillance data limits the ability of health authorities and vendors to implement targeted interventions. This study therefore aimed to investigate the occurrence of pathogenic bacteria and their antibiotic resistance patterns in RTE foods sold at the Federal University Wukari gate, with the following objectives: (i) to isolate and identify pathogenic bacteria present in the food samples; (ii) to determine the frequency of occurrence of the isolated pathogens; (iii) to assess the antibiotic susceptibility of the isolates against commonly prescribed antibiotics; and (iv) to identify multidrug-resistant strains among the isolated pathogens.

MATERIALS AND METHODS

Study Area and Design

This cross-sectional descriptive study was conducted at the Federal University Wukari gate, Wukari Local Government Area, Taraba State, Nigeria (latitude 7.89°N, longitude 9.77°E), a guinea savannah zone with a mean elevation of 189 m, mean annual temperature of 26.8°C, and mean annual rainfall of 1,205 mm. The site hosts a high concentration of street food vendors serving students, staff, and visitors and was therefore considered representative for assessing RTE food safety. The study was carried out over a one-week sampling period.

Sample Collection

Seven commonly consumed RTE food types beans, egusi soup, jollof rice, ogbono soup, spaghetti, stew, and white rice were randomly collected in duplicate from selected cafeterias and canteens within the university gate vicinity. Samples were placed into

separate sterile sample containers, appropriately labelled, and transported immediately to the Biology Laboratory, Federal University Wukari, for bacteriological analysis.

Bacterial Isolation and Identification

One gram of each food sample was serially diluted in 9 mL sterile distilled water, and 0.5 mL aliquots of appropriate dilutions were inoculated onto nutrient agar and MacConkey agar by the pour-plate method. Plates were incubated aerobically at 37°C for 24 hours, and discrete colonies were purified by repeated sub-culturing on freshly prepared nutrient agar using the streak-plate method. Pure isolates were characterised by colonial morphology (size, colour, shape, elevation, pigmentation) and Gram-stained for microscopic examination under oil-immersion magnification (×100). Identification to genus/species level was confirmed using standard biochemical tests, including catalase, coagulase, and the IMViC battery (indole, methyl red, Voges–Proskauer, citrate utilisation), performed according to standard clinical microbiology protocols (Cheesbrough, 2009; Collee et al., 2016).

Total Viable Count

Total viable bacterial counts were determined from colony counts on nutrient agar plates and expressed as colony-forming units per millilitre (CFU/mL) of food sample for each of the seven food types.

Antibiotic Susceptibility Testing

Antibiotic susceptibility of all confirmed isolates was determined using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar, in line with Clinical and Laboratory Standards Institute (CLSI) guidelines. Standardised antibiotic-impregnated discs were used, comprising ciprofloxacin (5/10 μg), cefuroxime (30 μg), gentamycin (10 μg), rifampicin (20 μg), streptomycin (30 μg), ceftazidime (10/30 μg), erythromycin (30 μg), azithromycin (10 μg), levofloxacin (20 μg), amoxicillin (20 μg), ofloxacin (10 μg), augmentin (30 μg), peflacine (10 μg), ceporex (10 μg), and ceftriaxone (30 μg). Plates were incubated at 37°C for 24 hours, after which zones of inhibition were measured in millimetres and interpreted as susceptible or resistant according to CLSI breakpoints (CLSI, 2024).

Ethical Approval

Ethical clearance for the study was obtained from the Department of Biological Sciences, Faculty of Biosciences, Federal University Wukari. Written informed consent was

obtained from participating vendors after the study objectives and procedures had been explained.

Statistical Analysis

Data were summarised as frequencies and percentages. The chi-square (χ^2) test was used to assess whether the occurrence of bacterial isolates differed significantly across bacterial species and across food sample types, with $p < 0.05$ considered statistically significant. Analyses were performed using SPSS version 24 (IBM Corp., Armonk, NY, USA).

RESULTS

Bacterial Isolates and Morphological Characteristics

A total of 33 bacterial isolates were recovered from the seven RTE food samples examined. Biochemical and morphological characterisation identified four genera: Bacillus cereus, Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus (Tables 1 and 2).

Table 1. Morphological characteristics and Gram reaction of bacteria isolated from ready-to-eat food samples

Bacteria	Colony morphology	Gram reaction
Bacillus cereus	Small, moist, white/creamy colonies	Gram-positive rod
Escherichia coli	Moderate, moist, yellow lactose-fermenting colonies	Gram-negative rod
Pseudomonas aeruginosa	Moderate, moist, blue-green non-lactose fermenter colonies	Gram-negative rod
Staphylococcus aureus	Small, moist, yellow colonies	Gram-positive cocci

Table 2. Biochemical reactions of bacteria isolated from ready-to-eat food samples

Bacteria	Catalase	Coagulase	Indole	Methyl red	Citrate	Oxidase	Morphology
Bacillus cereus	+	−	−	−	+	−	Rod, G+
Escherichia coli	+	−	+	+	−	−	Rod, G−
Pseudomonas aeruginosa	+	−	−	−	+	+	Rod, G−
Staphylococcus aureus	+	+	−	+	+	−	Cocci, G+

Total Viable Bacterial Counts

Total viable counts of the food samples ranged from 1.0×10^6 to 4.0×10^6 CFU/mL. Stew recorded the highest bacterial load (4.0×10^6 CFU/mL), followed by spaghetti (2.7×10^6 CFU/mL), while egusi soup and white rice recorded the lowest loads (1.0×10^6 CFU/mL each) (Table 3).

Table 3. Total viable bacterial counts (CFU/mL) of ready-to-eat food samples

Food sample	Total viable count (CFU/mL)
Beans	1.7×10^6
Egusi soup	1.0×10^6
Jollof rice	1.5×10^6
Ogbono soup	1.2×10^6
Spaghetti	2.7×10^6
Stew	4.0×10^6
White rice	1.0×10^6

Frequency of Occurrence of Bacterial Isolates

Pseudomonas aeruginosa was the most frequently isolated organism, accounting for 16 of the 33 isolates (48.5%), followed by Staphylococcus aureus (9; 27.2%), Escherichia coli (5; 15.2%), and Bacillus cereus (3; 9.1%) (Table 4). The difference in occurrence among the four bacterial species was statistically significant ($\chi^2 = 5.926$, mean = 8.25, $p = 0.041$).

Table 4. Frequency of occurrence of bacteria isolated from ready-to-eat food samples

Bacteria	No. of isolates	Total isolates	Percentage (%)
Bacillus cereus	3	33	9.1
Escherichia coli	5	33	15.2
Pseudomonas aeruginosa	16	33	48.5
Staphylococcus aureus	9	33	27.2

Distribution of Isolates Across Food Samples

Stew harboured the highest number of isolates (7; 21.2%), followed by egusi soup (6; 18.2%); ogbono soup and spaghetti each yielded 5 isolates (15.2%); beans and jollof rice each yielded 4 isolates (12.1%); and white rice recorded the lowest contamination (2; 6.1%) (Table 5). The distribution of bacterial isolates among the food types was also statistically significant ($\chi^2 = 4.028$, mean = 4.71, $p = 0.025$).

Table 5. Occurrence of bacterial isolates in relation to ready-to-eat food sample type

Bacteria	BN	EG	JO	OG	SP	ST	WR	Total
Bacillus cereus	–	–	–	–	3	–	–	3
Escherichia coli	3	–	–	–	2	–	–	5
Pseudomonas aeruginosa	1	6	4	2	–	2	1	16
Staphylococcus aureus	–	–	–	3	–	5	1	9
Total (%)	4 (12.1%)	6 (18.2%)	4 (12.1%)	5 (15.2%)	5 (15.2%)	7 (21.2%)	2 (6.1%)	33

Key: BN = Beans, EG = Egusi soup, JO = Jollof rice, OG = Ogbono soup, SP = Spaghetti, ST = Stew, WR = White rice.

Antibiotic Susceptibility Profile

Antibiogram testing showed that the Gram-positive isolates (Bacillus cereus and Staphylococcus aureus) were broadly susceptible to ciprofloxacin and levofloxacin, but Staphylococcus aureus isolates were uniformly resistant to cefuroxime and ceftazidime and showed substantial resistance to erythromycin, consistent with reduced activity of older β-lactams and macrolides against staphylococcal isolates from this setting (Table 6). Among Gram-negative isolates, ciprofloxacin again showed the broadest activity against both Escherichia coli and Pseudomonas aeruginosa, while augmentin retained partial activity. In contrast, cefuroxime, gentamycin, ceftazidime, and ceftriaxone showed comparatively higher resistance, particularly among Escherichia coli isolates (Table 7).

Table 6. Antibiogram (zone of inhibition, mm) of Gram-positive bacteria isolated from ready-to-eat food samples

Bacteria		CPX	CEF	CN	RD	S	CTZ	ERY	AZM	LEV
Bacillus cereus (n=3)	S	17	0	5	0	16	0	5	0	18
	R	5	3	0	7	3	9	6	4	4
Staphylococcus aureus (n=9)	S	21	0	4	18	19	0	5	14	22
	R	0	9	10	0	3	14	8	3	0

Key: S = Susceptible (zone of inhibition, mm); R = Resistant. CPX = Ciprofloxacin, CEF = Cefuroxime, CN = Gentamycin, RD = Rifampicin, S = Streptomycin, CTZ = Ceftazidime, ERY = Erythromycin, AZM = Azithromycin, LEV = Levofloxacin.

Table 7. Antibiogram (zone of inhibition, mm) of Gram-negative bacteria isolated from ready-to-eat food samples

Bacteria		CPX	CEF	CN	OFX	S	CTZ	AU	PEF	TRX
Escherichia coli (n=5)	S	23	0	0	0	0	0	18	20	0
	R	5	13	10	7	13	9	4	3	15
Pseudomonas aeruginosa (n=16)	S	30	0	0	19	12	0	28	22	0
	R	0	9	10	0	3	14	0	3	9

Key: S = Susceptible (zone of inhibition, mm); R = Resistant. CPX = Ciprofloxacin, CEF = Cefuroxime, CN = Gentamycin, OFX = Ofloxacin, S = Streptomycin, CTZ = Ceftazidime, AU = Augmentin, PEF = Peflacine, TRX = Ceftriaxone.

DISCUSSION

This study assessed the bacteriological quality and antibiotic susceptibility patterns of RTE foods sold around the Federal University Wukari gate. The recovery of 33 isolates spanning four genera, all of recognised public-health significance, confirms that these foods are microbiologically unsafe at the point of sale and aligns with comparable reports from other Nigerian university communities and markets (Onohuean et al., 2025; Makinde et al., 2021).

Pseudomonas aeruginosa was the predominant isolate (48.5%), suggesting environmental rather than purely human-source contamination, since this organism is ubiquitous in soil, water, and on food-contact surfaces and frequently enters food via contaminated utensils or water used during preparation (Makinde et al., 2021). Its high zone of inhibition to ciprofloxacin in this study suggests it remains treatable with fluoroquinolones in this setting, although its resistance to several β-lactams is consistent with the intrinsic and acquired β-lactamase-mediated resistance widely documented in this species (Tacconelli et al., 2025).

The relatively high occurrence of Staphylococcus aureus (27.2%) implicates food handlers as a contamination source, since this organism is commonly carried on human skin and nasal passages and is readily transferred to food during preparation and serving (Akinyele et al., 2024). The marked resistance of S. aureus isolates to cefuroxime and erythromycin observed here mirrors the broader pattern of β-lactam and macrolide resistance reported among staphylococcal isolates from RTE foods elsewhere in Nigeria, and is consistent with global concern over methicillin- and macrolide-resistant S. aureus as a foodborne hazard (Onohuean et al., 2025).

The detection of Escherichia coli (15.2%) is of particular concern because this organism is a recognised indicator of faecal contamination, implicating either the water used in food preparation or inadequate hand hygiene among vendors (Makinde et al., 2021). The comparatively higher resistance of E. coli isolates to cephalosporins (cefuroxime, ceftazidime, ceftriaxone) than to fluoroquinolones in this study is consistent with regional surveillance showing rising extended-spectrum β-lactamase-mediated

resistance among Enterobacteriaceae recovered from RTE foods across West Africa (Onohuean et al., 2025).

Although Bacillus cereus recorded the lowest occurrence (9.1%), its presence remains clinically relevant because this organism produces heat-resistant spores capable of surviving cooking and subsequently germinating in improperly stored cooked foods, a mechanism well documented for starch-rich dishes similar to those sampled in this study (Cheesbrough, 2009).

The statistically significant difference in bacterial occurrence among food types ($p = 0.025$), with stew and egusi soup the most heavily contaminated, is consistent with previous reports that soups and stews sold by street vendors accumulate higher microbial loads owing to repeated handling during dispensing, prolonged holding at ambient temperature, and the combination of multiple ingredients during preparation (Oranusi and Braide, 2012). The correspondingly high total viable count recorded for stew (4.0×10^6 CFU/mL) and spaghetti (2.7×10^6 CFU/mL) further supports the conclusion that prolonged holding time and repeated handling, rather than the raw ingredients alone, are the principal drivers of contamination in this setting.

Taken together, the antibiogram results show that ciprofloxacin and levofloxacin retained the broadest activity across all four genera, while resistance was concentrated among the older β-lactams and first-generation cephalosporins. This pattern is consistent with the wider regional and global trend in which fluoroquinolones remain comparatively effective against many foodborne Gram-negative and Gram-positive pathogens, even as resistance to β-lactams continues to rise, a trend the WHO Bacterial Priority Pathogens List (2024) and the most recent Global Burden of Disease AMR analysis both identify as a continuing driver of difficult-to-treat foodborne infection worldwide (Tacconelli et al., 2025; GBD 2021 Antimicrobial Resistance Collaborators, 2024). These findings reinforce that RTE foods sold around the university gate are not only a direct source of acute foodborne illness but may also function as an environmental reservoir contributing to the wider spread of antibiotic-resistant bacteria within the university community.

CONCLUSION

Ready-to-eat foods sold around the Federal University Wukari gate are contaminated with Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli, and Bacillus cereus, with occurrence and distribution patterns that differ significantly by bacterial species and by food type. Stew and egusi soup were the most heavily contaminated foods, and total viable counts across all samples substantially exceeded levels consistent with safe consumption. Antibiogram profiling showed that fluoroquinolones (ciprofloxacin, levofloxacin) remain broadly effective against the isolated pathogens, whereas resistance was concentrated among β-lactam agents. These findings confirm that RTE foods vended around the study area pose a tangible risk of foodborne illness and may contribute to the local burden of antimicrobial-resistant bacteria.

Recommendations

Based on these findings, the following measures are recommended:

1. Food vendors should receive structured training in food hygiene and safe handling practices to reduce microbial contamination of RTE foods.
2. Vendors should observe strict personal hygiene, including routine hand washing and use of clean protective clothing during food preparation and serving.
3. RTE foods should be covered and protected from dust, flies, and other environmental contaminants throughout vending.
4. Only clean, potable water should be used in food preparation, and all utensils and preparation surfaces should be properly washed and sanitised.
5. Relevant health authorities should institute regular inspection and monitoring of vending sites to enforce compliance with food-safety standards.
6. Further studies incorporating molecular characterisation of resistance genes are recommended to clarify the mechanisms underlying the resistance patterns observed in this and similar university settings.

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