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Physicochemical Characteristics and Predicted Spoilage Susceptibility of Selected Nigerian Street-Vended Foods: Implications for Shelf-Life Stability and Food Safety

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Abstract: *Street-vended foods constitute an important component of urban diets in developing countries, yet information on their physicochemical quality and spoilage susceptibility remains limited. This study evaluated the physicochemical characteristics and inferred microbial stability of selected Nigerian ready-to-eat street foods using moisture content, ash content, and pH as indicators associated with shelf-life behavior and spoilage susceptibility. Fourteen commonly consumed street-vended foods comprising fried products (n = 5), bakery products (n = 5), and fermented/starch-based foods (n = 4) were analyzed using standard oven-drying, dry-ashing, and potentiometric methods. Data were expressed as mean ± standard deviation and analyzed using one-way analysis of variance (ANOVA) at $p < 0.05$. Moisture content varied significantly ($p < 0.05$) among food samples, ranging from 12.8 ± 0.8% in garri to 74.6 ± 2.5% in kunu. Fermented foods exhibited the highest moisture contents (62.3–74.6%), followed by fried foods (26.9–35.2%) and bakery products (22.6–34.8%). Ash content ranged from 1.3 ± 0.1% (garri) to 2.9 ± 0.2% (kunu), with fermented foods and fried fish recording the highest values. Significant differences ($p < 0.05$) were also observed in pH values, which ranged from 4.0 ± 0.1 to 6.6 ± 0.1. Fermented foods were acidic (pH 4.0–5.2), whereas fried and bakery products exhibited near-neutral pH values (5.8–6.6). Garri (pH 4.0 ± 0.1) and ogi (pH 4.2 ± 0.1) showed the greatest acidity, while puff-puff (pH 6.6 ± 0.1) and fried plantain (pH 6.5 ± 0.1) recorded the highest pH values. Integrated evaluation of moisture content and pH indicated that foods characterized by elevated moisture content and near-neutral pH may exhibit greater predicted spoilage susceptibility under ambient storage conditions. Conversely, fermented foods, despite their high moisture contents, demonstrated comparatively lower predicted spoilage susceptibility due to their acidic nature. Based on physicochemical profiling, garri was classified as having low predicted spoilage risk, whereas bread, fried fish, fried plantain, fried yam, and buns exhibited comparatively higher predicted spoilage susceptibility. The findings demonstrate that moisture–pH interactions are important determinants of inferred microbial stability and shelf-life behavior in street-vended foods. Physicochemical profiling provides a rapid and cost-effective approach for preliminary assessment of food quality and spoilage risk in resource-limited settings and may support improved food safety monitoring and public health protection.*

Keywords: *Street-vended foods; Physicochemical quality; Moisture content; Ash content; pH; Predicted microbial stability; Spoilage susceptibility; Shelf-life assessment; Food safety; Public health.*

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1.0 Introduction

Street-vended foods constitute an indispensable component of urban dietary intake in many developing countries, providing affordable and readily accessible meals to rapidly growing urban populations. In many African urban centers, including Nigeria, these foods are widely consumed by students, workers, and low-income populations because of their accessibility and low cost (Kaddouri *et al*., 2025). However, street foods are often prepared, displayed, and sold under informal conditions where environmental control, processing standardization, and storage regulation are limited, thereby raising concerns regarding food quality, spoilage susceptibility, and public health safety (Kaddouri *et al*., 2025). The World Health Organization has consistently identified street-vended foods as an important component of urban food systems that require enhanced food safety monitoring because of their potential role in foodborne disease transmission.

The physicochemical quality of food is a fundamental determinant of shelf-life stability, sensory acceptability, microbial ecology, and overall food safety. Parameters such as moisture content, ash content, and pH provide insight into water availability, mineral composition, and hydrogen ion concentration, respectively, all of which influence microbial persistence and spoilage kinetics in food systems (Liu, 2013). Moisture content is particularly important because it directly influences water activity, a critical factor governing microbial proliferation, biochemical reactions, and enzymatic deterioration in foods (Tarlak, 2023). High-moisture foods are generally more susceptible to microbial spoilage and pathogen persistence because increased water availability supports microbial growth, enzymatic activity, and biochemical degradation processes. (Purice *et al*., 2024). Conversely, low-moisture foods often exhibit improved shelf stability, although deterioration through lipid oxidation, hydrolytic degradation, and non-enzymatic browning may still occur during storage (Liu *et al*., 2022; Rezaei & Vandergheynst, 2010).

"Among intrinsic food properties, pH is one of the most influential factors governing microbial growth dynamics, survival, and spoilage potential (Lima *et al*., 2023). Most pathogenic and spoilage-associated microorganisms exhibit optimal growth under near-neutral pH conditions, whereas acidic food environments suppress microbial proliferation and reduce metabolic activity (Mengistu *et al*., 2022; Qi *et al*., 2026). Fermentation processes therefore contribute significantly to food preservation through acidification and ecological suppression of undesirable microorganisms (Gänzle *et al*., 2025). The interaction between moisture availability and acidity may also influence the ecological selection of spoilage-associated microorganisms in fermented and non-fermented food systems (Racchi *et al*., 2020). These physicochemical interactions may shape microbial community composition, survival dynamics, and metabolic activity within ready-to-eat food matrices.

Predictive microbiology approaches increasingly integrate physicochemical parameters such as moisture content, pH, and water activity to estimate microbial behavior and spoilage susceptibility in food matrices, particularly in resource-limited environments where routine microbiological testing may not always be feasible (Tarlak, 2023; Pampoukis *et al*., 2022). Physicochemical conditions also influence food microbiome stability by selectively favoring acid-tolerant, osmoresistant, or spoilage-associated microbial populations during storage (Tan *et al*., 2025). These approaches provide scientifically robust and cost-effective preliminary indicators for assessing spoilage risk and microbial persistence. Although direct microbiological enumeration remains the gold standard for contamination assessment, physicochemical profiling offers an important low-cost framework for preliminary food safety evaluation and spoilage-risk prediction (Olagoke-Komolafe & Oyeboade, 2024).

Ash content represents the total inorganic mineral residue remaining after complete combustion of organic matter and serves as an indicator of nutritional composition, processing quality, and potential environmental contamination. (Adamczyk *et al*., 2023; Marshall, 2010). Variations in ash content may arise from differences in ingredient composition, processing methods, handling practices, and exposure to environmental particulates during food preparation and vending (Agrawal *et al*., 2025). Elevated ash levels in street-vended foods may also reflect contamination associated with dust deposition, soil particles, cooking water impurities, or open-air environmental exposure (Li, 2025).

Street food systems are strongly influenced by preparation practices, ingredient composition, ambient environmental conditions, and post-processing handling (Barimah *et al*., 2026). Exposure to fluctuating temperatures, humidity, dust, and prolonged open-air display may alter moisture balance and physicochemical stability, thereby increasing spoilage susceptibility and microbial persistence (Olagoke-Komolafe & Oyeboade, 2024). Several studies have shown that ready-to-eat street foods frequently exhibit elevated moisture content and variable pH conditions capable of supporting microbial survival if storage and handling conditions are inadequate (Ebrahim & Wondimagegn, 2025). Inconsistent thermal processing and prolonged holding times may further compromise food stability and increase foodborne health risks (Dhudum & Bhosale, 2025).

In many Nigerian urban settings, street-vended foods are frequently consumed immediately after purchase without additional preservation or refrigeration, increasing the likelihood of environmental exposure and physicochemical deterioration (Amadi-Ikpa *et al*., 2023). Limited refrigeration infrastructure, prolonged ambient storage, and inconsistent hygienic handling practices may therefore contribute significantly to spoilage susceptibility and foodborne disease transmission in informal food systems (Alimi, 2016; Negassa *et al*., 2023). Furthermore, environmental contaminants introduced during vending operations may adversely affect both food quality and consumer safety. Given the increasing dependence on ready-to-eat street foods in Nigerian cities, understanding the physicochemical attributes that may influence spoilage susceptibility is essential for supporting food quality assurance and public health protection.

From a food microbial ecology perspective. , physicochemical parameters such as moisture availability and acidity strongly influence microbial survival patterns, spoilage progression, and food matrix stability (Schiraldi, 2025). Foods with elevated moisture content and near-neutral pH may provide favorable conditions for microbial persistence, whereas acidic fermented foods may exhibit comparatively improved microbial stability despite high moisture levels (Racchi *et al*., 2020; Gänzle *et al*., 2025). Consequently, integrated physicochemical profiling has emerged as a valuable approach for understanding shelf-life behavior, microbial stability, and spoilage-risk prediction in ready-to-eat foods (Parente & Ricciardi, 2025).

Despite increasing concerns regarding foodborne illnesses associated with informal food systems, most studies on street-vended foods have focused primarily on microbiological contamination, hygienic practices, and foodborne pathogens. Comparatively few investigations have examined how physicochemical parameters such as moisture content, ash content, and pH collectively influence predicted microbial stability and spoilage susceptibility, particularly within Nigerian street-food systems. Consequently, integrated predictive assessments linking physicochemical characteristics with inferred microbial behavior remain poorly characterized. Therefore, the aim of this study was to evaluate the moisture content, ash content, and pH characteristics of selected Nigerian street-vended foods and to assess their implications for predicted microbial stability and spoilage susceptibility using a physicochemical profiling approach. The findings are expected to provide baseline information for food quality assessment, support low-cost monitoring strategies in resource-constrained settings, and contribute to improved food safety surveillance and public health protection.

2. 0 Material and Methods

2.1 Study Design

This study employed a cross-sectional experimental design to evaluate the physicochemical quality and microbial stability indicators of selected Nigerian street-vended foods. The study focused on key shelf-life parameters including moisture content, ash content, and pH as indicators of spoilage risk and environmental exposure.

2.2 Study Area

The study was conducted in Ado-Ekiti, Ekiti State, Nigeria. Ado-Ekiti is an urban centre with a high concentration of street food vending activities, where ready-to-eat foods are commonly prepared and sold under informal conditions with limited environmental control. The city is located approximately between latitude 7°37'N and longitude 5°13'E and serves as the administrative capital of Ekiti State. The area was selected due to its active street food culture and high consumer reliance on such foods.

2.3 Sample Selection and Collection

Street-vended foods were selected based on their popularity and frequency of consumption. Samples were grouped into three categories:

- Oil-based fried foods (5 samples): akara, puff-puff, fried yam, fried plantain (dodo), fried fish
- Baked/confectionery foods (5 samples): bread, meat pie, buns, cake, doughnuts
- Fermented/starch-based foods (4 samples): ogi, garri, kunu, and fufu.
-

Freshly prepared ready-to-eat portions (approximately 100–200 g per sample) were purchased from vendors and collected into sterile polyethylene bags. Three independent vendors were sampled for each food type, yielding three analytical replicates per food category. Samples were transported immediately to the laboratory and analyzed within 2 h of collection.

2.4 Sample Preparation

Each food sample was homogenized using a sterile mortar and pestle. The homogenized material was subdivided into portions for moisture content, ash content, and pH analysis to ensure consistency across all measurements. Mortar, pestle, and preparation surfaces were cleaned with distilled water and air-dried between sample preparations to minimize cross-contamination.

2.5 Determination of Moisture Content

Moisture content was determined according to the AOAC oven-drying method (AOAC, 2023) at 105°C. Sample weights were measured using a digital analytical balance with ±0.001 g precision.

Approximately 5.0 g of each homogenized sample was weighed into pre-weighed moisture dishes and dried in a hot-air oven at 105°C until constant weight was achieved. Samples were cooled in a desiccator and reweighed. Constant weight was defined as two consecutive measurements differing by less than 0.005 g. Moisture content (%) was calculated using:

$$\text{Moisture content} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \qquad (1)$$

2.6 Determination of Ash Content

Ash content was determined according to the AOAC dry-ashing method (AOAC, 2023) Ash content was determined by dry ashing using a Thermolyne muffle furnace operated at 550°C until a constant light-grey ash was obtained.

About 2.0–3.0 g of each dried sample was placed in pre-weighed crucibles, gently charred, and then incinerated in a muffle furnace at 550°C for 4–6 hours until a light grey or white ash was obtained. Crucibles were cooled in a desiccator and reweighed.

Ash content (%) was calculated as:

$$\text{Ash content} = \frac{\text{Weight of ash}}{\text{Initial sample weight}} \times 100 \qquad (2)$$

2.7 Determination of pH

The pH of each sample was measured using a Jenway digital pH meter. The pH meter was calibrated using standard buffer solutions of pH 4.0, 7.0, and 10.0 prior to analysis.

Ten grams of sample was homogenized in 50 mL of distilled water and filtered. The pH electrode was immersed in the filtrate, and readings were recorded after stabilization.

Calibration of the pH meter was performed using standard buffer solutions (pH 4.0, 7.0, and 10.0) before analysis.

2.8 Quality Control and Assurance

All balances and analytical equipment were verified for proper operation prior to use. All analyses were conducted independently in triplicate, and mean values were calculated from replicate determinations to ensure accuracy and reproducibility. Glassware was thoroughly cleaned and rinsed with distilled water before use. The pH meter was recalibrated regularly, and moisture and ash analyses were performed under controlled laboratory conditions.

2.9 Predictive Interpretation of Microbial Stability

Microbial stability was not directly measured but was inferred using established predictive microbiology principles relating moisture availability and pH to microbial growth potential. Foods characterized by relatively high moisture content and near-neutral pH were interpreted as exhibiting greater theoretical susceptibility to microbial persistence and spoilage under ambient storage conditions, whereas foods with lower moisture content or acidic pH values were considered comparatively less supportive of microbial proliferation. These interpretations were used solely as preliminary indicators and not as direct measures of microbiological contamination.

Interpretations were based on predictive microbiology principles described by Tarlak (2023), Parente and Ricciardi (2025), and Pampoukis *et al*. (2022).

2.10 Data Analysis

Data were expressed as mean ± standard deviation (SD). One-way analysis of variance (ANOVA) was performed to compare physicochemical parameters among food categories. Differences were considered statistically significant at $p < 0.05$. Pearson correlation analysis was additionally used to evaluate associations between moisture content and pH as indicators associated with predicted microbial spoilage susceptibility. Statistical analyses were conducted using SPSS version 29 (IBM Corp., USA).

3.0 Results and Discussion

3.1 Moisture Content of Selected Street Foods

The moisture content of selected Nigerian street foods showed clear variation across food categories, reflecting differences in processing methods, formulation, and storage stability. Fermented foods exhibited the highest moisture levels, followed by bakery products, while fried foods generally showed reduced moisture content due to thermal dehydration during processing.

Moisture content ranged from 12.8 ± 0.8% (garri) to 74.6 ± 2.5% (kunu). Fried foods recorded intermediate values (26.9–35.2%), while bakery foods ranged between 22.6–

34.8%. High-moisture foods such as kunu, ogi, and fufu indicate elevated susceptibility to microbial spoilage and reduced shelf stability. These findings are summarized in **Table 1**, while the comparative distribution is illustrated in **Fig. 1** (Moisture Content Distribution of Selected Street Foods).

ANOVA revealed significant differences in moisture content among food categories ($p < 0.05$).

Table 1: Moisture content (%) of selected street foods

Food Category	Sample	Moisture Content (%) Mean ± SD
Fried foods	Akara	28.4 ± 1.2
Fried foods	Puff-puff	26.9 ± 1.0
Fried foods	Fried yam	32.1 ± 1.4
Fried foods	Fried plantain	30.5 ± 1.3
Fried foods	Fried fish	35.2 ± 1.6
Bakery foods	Bread	34.8 ± 1.5
Bakery foods	Meat pie	22.6 ± 1.1
Bakery foods	Buns	31.7 ± 1.3
Bakery foods	Cake	29.9 ± 1.2
Bakery foods	Doughnuts	27.5 ± 1.1
Fermented foods	Ogi	68.4 ± 2.3
Fermented foods	Garri	12.8 ± 0.8
Fermented foods	Kunu	74.6 ± 2.5
Fermented foods	Fufu	62.3 ± 2.1

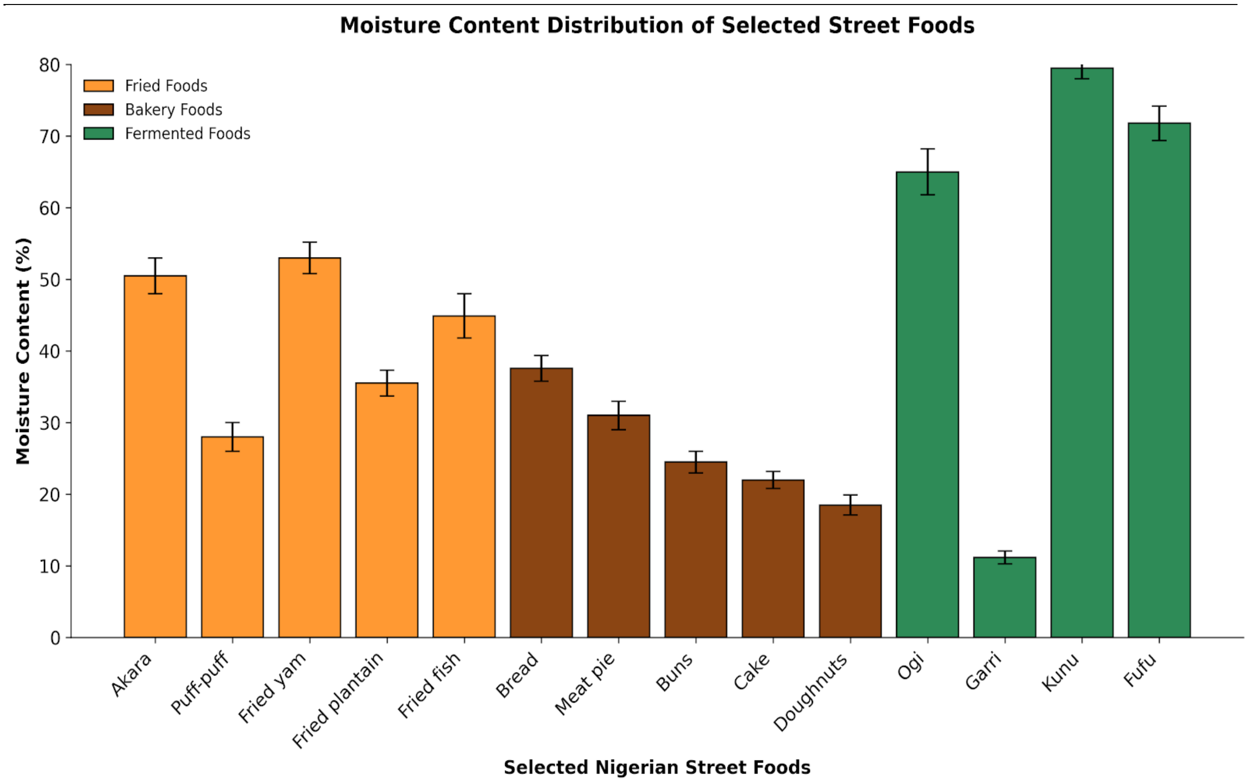

Fig. 1: Moisture Content Distribution of Selected Street Foods

3.2 Ash Content of Selected Street Foods

Ash content varied across food types, reflecting differences in mineral composition, ingredient formulation, and possible environmental contamination during preparation and vending. Fermented foods exhibited relatively higher ash values, while bakery and fried foods showed moderate levels.

Ash content ranged from 1.3 ± 0.1% (garri) to 2.9 ± 0.2% (kunu). Fried fish exhibited elevated ash content (2.8 ± 0.2%), likely reflecting its naturally higher mineral composition. Lower ash values in some bakery products suggest refined ingredient composition. Ash content also varied significantly across food categories ($p < 0.05$). These results are presented in **Table 2**, with comparative trends shown in **Fig. 2** (Ash Content Profile of Selected Street Foods).

3.3 pH of Selected Street Foods

The pH values of selected street foods demonstrated distinct differences between fermented and non-fermented products. Fermented foods exhibited acidic pH values ranging from 4.0 ± 0.1 to 5.2 ± 0.1, while fried and bakery foods were closer to neutral, ranging from 5.8 ± 0.1 to 6.6 ± 0.1.

Garri (4.0 ± 0.1) and ogi (4.2 ± 0.1) showed the lowest pH values, indicating conditions potentially associated with lower predicted spoilage susceptibilitydue to acidic conditions. In contrast, puff-puff (6.6 ± 0.1) and akara (6.4 ± 0.1) showed near-neutral pH, which may support conditions associated with microbial growth under ambient conditions. These findings are summarized in **Table 3**, with graphical representation in **Fig. 3** (pH Profile of Selected Street Foods and Predicted Microbial Stability indicators). Fermented foods exhibited significantly lower pH values compared with fried and bakery products ($p < 0.05$). An inverse relationship was observed between acidity and predicted spoilage susceptibility among fermented food samples.

Table 2: Ash content (%) of selected street foods

Food Category	Sample	Ash Content (%) Mean ± SD
Fried foods	Akara	2.3 ± 0.1
Fried foods	Puff-puff	1.8 ± 0.1
Fried foods	Fried yam	1.5 ± 0.1
Fried foods	Fried plantain	1.6 ± 0.1
Fried foods	Fried fish	2.8 ± 0.2
Bakery foods	Bread	2.1 ± 0.1
Bakery foods	Meat pie	1.9 ± 0.1
Bakery foods	Buns	2.0 ± 0.1
Bakery foods	Cake	1.7 ± 0.1
Bakery foods	Doughnuts	1.6 ± 0.1
Fermented foods	Ogi	2.6 ± 0.2
Fermented foods	Garri	1.3 ± 0.1
Fermented foods	Kunu	2.9 ± 0.2
Fermented foods	Fufu	2.4 ± 0.1

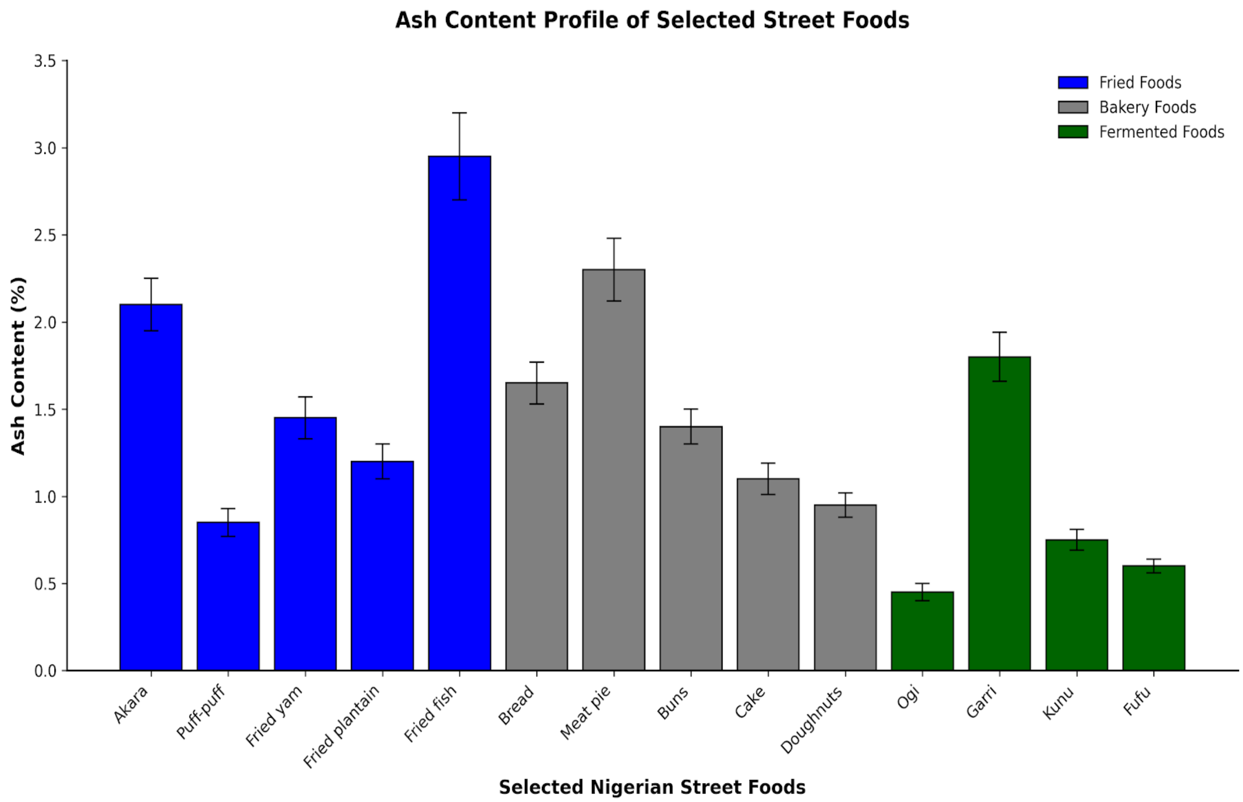

Fig. 2: Ash Content Profile of Selected Street Food

Table 3: pH values of selected street foods

Food Category	Sample	pH Mean ± SD
Fried foods	Akara	6.4 ± 0.1
Fried foods	Puff-puff	6.6 ± 0.1
Fried foods	Fried yam	6.3 ± 0.1
Fried foods	Fried plantain	6.5 ± 0.1
Fried foods	Fried fish	6.2 ± 0.1
Bakery foods	Bread	5.8 ± 0.1
Bakery foods	Meat pie	6.1 ± 0.1
Bakery foods	Buns	6.0 ± 0.1
Bakery foods	Cake	6.3 ± 0.1
Bakery foods	Doughnuts	6.4 ± 0.1
Fermented foods	Ogi	4.2 ± 0.1
Fermented foods	Garri	4.0 ± 0.1
Fermented foods	Kunu	4.5 ± 0.1
Fermented foods	Fufu	5.2 ± 0.1

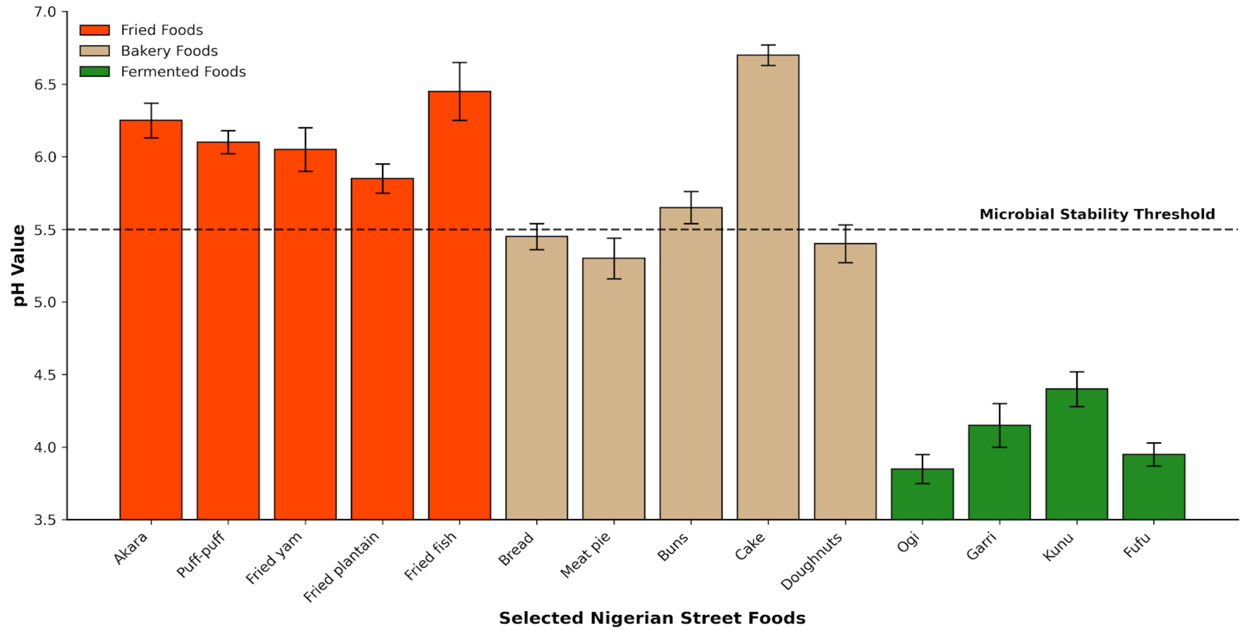

Fig. 3: pH Profile of Selected Street Foods and Microbial Stability Indicators

3.4 Integrated Moisture–pH Patterns Associated with Predicted Microbial Spoilage Risk

An integrated evaluation of moisture content and pH revealed a clear relationship between physicochemical properties and potential microbial stability. Foods with high moisture content and near-neutral pH (e.g., fried fish, bread, buns) exhibited higher theoretical spoilage risk, while fermented foods, despite high moisture, demonstrated improved stability due to acidic pH conditions. This relationship is illustrated in **Fig. 4** (Moisture–pH Relationship and Shelf-Life Stability Map). These interpretations represent predictive physicochemical associations and do not constitute direct microbiological confirmation.

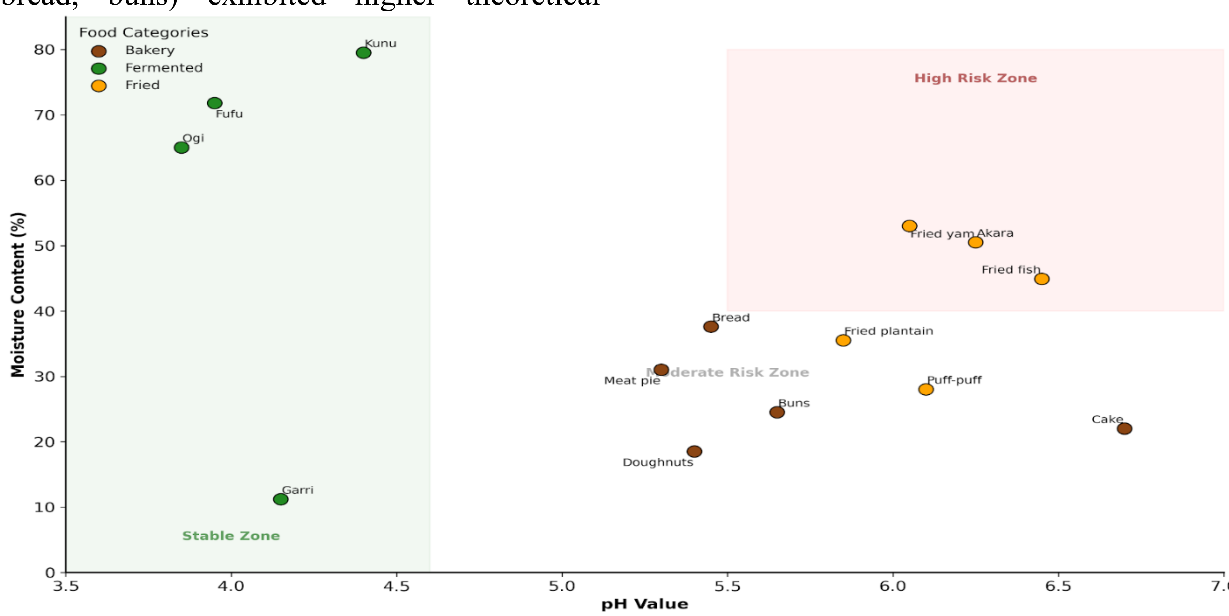

Fig. 4: Moisture–pH Relationship and Shelf-Life Stability Map of Selected Street Foods

4.0 Discussion

The present study assessed the physicochemical quality and inferred microbial stability of selected street-vended foods using moisture content, ash content, and pH as primary shelf-life indicators. The results highlight clear compositional differences across fried, bakery, and fermented food categories, reflecting variations in processing intensity, formulation, and exposure to environmental conditions.

4.1 Moisture Content and Shelf-Life Stability

Moisture content is a critical determinant of microbial stability because it directly influences water activity, which governs microbial proliferation and enzymatic spoilage reactions. In this study, fermented foods exhibited the highest moisture levels (62.3–74.6%), particularly kunu and ogi as shown in Table 1 and Fig. 1, indicating a high-risk category for microbial spoilage under ambient storage conditions.

Bakery foods showed moderate moisture content (22.6–34.8%), while fried foods also displayed intermediate values (26.9–35.2%), reflecting partial dehydration during frying. Similar patterns have been reported in recent food stability studies where high-moisture traditional beverages were identified as highly perishable due to rapid microbial growth under tropical conditions [21,22].

The moisture distribution in Fig. 1 suggests that foods containing relatively high moisture levels may be more susceptible to physicochemical deterioration and microbial persistence than lower-moisture products. Moisture-dependent spoilage susceptibility has been widely utilized in predictive microbiology frameworks to estimate the likelihood of microbial persistence in food matrices. Foods with elevated moisture content may provide favorable physicochemical conditions for bacterial and fungal survival, particularly under tropical ambient conditions.

Elevated moisture conditions may enhance microbial persistence by supporting nutrient diffusion, enzymatic metabolism, and cellular proliferation of spoilage-associated bacteria and fungi.

4.2 Ash Content and Environmental Exposure

Ash content reflects total mineral composition but also serves as an indirect indicator of raw material quality, processing conditions, and possible environmental contamination. The ash content in this study ranged from 1.3% to 2.9%, as presented in Table 2 and Fig. 2.

Fermented foods such as kunu and ogi recorded higher ash values (2.6–2.9%), which may reflect both ingredient composition and exposure to environmental particulates during preparation and vending. Fried fish also showed elevated ash content (2.8%), suggesting possible contribution from processing water quality and handling conditions.

Recent studies have shown that street-vended foods often exhibit elevated mineral residues due to dust exposure, unregulated water sources, and open-air preparation systems (Nikiema *et al*., 2007; Daramola, 2025). The pattern observed in **Fig. 2** supports the role of environmental exposure as a key determinant of physicochemical variability in informal food systems.

Acidic conditions in fermented foods may exert selective pressure favoring acid-tolerant microbial populations while suppressing many spoilage and pathogenic organisms.

4.3 pH and Microbial Stability

pH is one of the most important intrinsic factors controlling microbial growth. Foods with low pH values tend to resist microbial proliferation, while near-neutral pH foods are more susceptible to spoilage organisms.

In this study, fermented foods showed acidic pH values (4.0–5.2), as shown in **Table 3** and **Fig. 3**, indicating higher inherent microbial stability. In contrast, fried and bakery foods exhibited near-neutral pH ranges (5.8–6.6), which fall within optimal growth conditions for many bacteria and fungi.

This aligns with recent findings that pH values above 5.5 significantly increase spoilage risk in ready-to-eat foods stored under ambient tropical conditions (Qi *et al*., 2026; Akpoka *et al*., 2019). The acidic nature of fermented foods therefore provides a natural preservation mechanism through microbial inhibition and reduced enzymatic activity. Similar observations have been reported for fermented cereal-based foods and traditional beverages in tropical environments, where acidification contributes substantially to shelf-life extension and suppression of spoilage-associated microorganisms.

The combined influence of moisture and acidity likely contributes to ecological filtering of microbial populations within street-vended food systems. The combined occurrence of elevated moisture content and near-neutral pH may increase the potential for microbial persistence, thereby elevating predicted spoilage susceptibility and associated public health concerns.

4.4 Integrated Moisture–pH Interaction and Shelf-Life Risk

The combined analysis of moisture content and pH provides a more realistic assessment of shelf-life stability than individual parameters. As illustrated in **Fig. 4**, foods with both high moisture and near-neutral pH (e.g., bread, buns, fried fish) present the highest spoilage risk category. These observations reinforce the importance of evaluating multiple physicochemical parameters simultaneously when assessing food quality and spoilage susceptibility.

Conversely, fermented foods despite their high moisture content exhibited improved stability due to acidic pH conditions, demonstrating that acidity can partially offset water-driven microbial risk. This interaction is consistent with established food microbiology principles where both water activity and hydrogen ion concentration jointly regulate microbial survival (Schiraldi, 2025; Sperber, 2009).

Table 4. Predicted Spoilage Risk Classification of Selected Street Foods

Food	Moisture Content (%)	pH	Predicted Spoilage Risk
Akara	28.4 ± 1.2	6.4 ± 0.1	Moderate–High
Puff-puff	26.9 ± 1.0	6.6 ± 0.1	Moderate–High
Fried yam	32.1 ± 1.4	6.3 ± 0.1	High
Fried plantain	30.5 ± 1.3	6.5 ± 0.1	High
Fried fish	35.2 ± 1.6	6.2 ± 0.1	High
Bread	34.8 ± 1.5	5.8 ± 0.1	High
Meat pie	22.6 ± 1.1	6.1 ± 0.1	Moderate
Buns	31.7 ± 1.3	6.0 ± 0.1	High
Cake	29.9 ± 1.2	6.3 ± 0.1	Moderate–High
Doughnuts	27.5 ± 1.1	6.4 ± 0.1	Moderate–High
Ogi	68.4 ± 2.3	4.2 ± 0.1	Moderate
Garri	12.8 ± 0.8	4.0 ± 0.1	Low
Kunu	74.6 ± 2.5	4.5 ± 0.1	Moderate
Fufu	62.3 ± 2.1	5.2 ± 0.1	Moderate–High

Recent predictive shelf-life models emphasize that multi-parameter systems provide more accurate spoilage predictions than single-factor approaches (Parente & Ricciardi, 2025).

These findings support emerging predictive microbiology approaches that utilize intrinsic food properties for rapid spoilage-risk estimation in low-resource food safety systems. Risk classification was inferred from the combined interaction of moisture content and pH using predictive microbiology principles. Foods with elevated moisture content and near-neutral pH were categorized as having higher predicted spoilage susceptibility, whereas acidic foods demonstrated comparatively improved predicted microbial stability despite high moisture levels as shown in **Table 4.**

4.5 Environmental and Public Health Implications

The physicochemical variability observed in this study has important implications for public health, particularly in urban environments where street foods are consumed daily. High-moisture foods displayed under ambient conditions are highly susceptible to microbial contamination risk, especially in warm and humid climates.

Foodborne illness outbreaks in informal food systems have been strongly linked to improper storage, high moisture content, and insufficient acidification (Negassa *et al*., 2023; Ahmed *et al*., 2024). The near-neutral pH observed in several fried and bakery products suggests that these foods may provide physicochemical conditions favorable for microbial proliferation if consumed after prolonged exposure.

Furthermore, ash content variability suggests possible environmental contamination pathways, including dust deposition, unregulated water use, and poor hygienic handling practices. These findings align with studies indicating that environmental exposure significantly influences microbial and physicochemical food quality in street vending systems (Tan *et al*., 2025; Nonga *et al*., 2015).

4.6 Shelf-Life Chemistry Perspective

From a chemical stability standpoint, moisture facilitates hydrolytic reactions, while pH influences enzymatic stability and microbial metabolic activity. The combined effects observed in this study suggest that spoilage susceptibility in street-vended foods appears to be strongly influenced by water–acid interactions. High moisture foods such as kunu and ogi undergo rapid biochemical degradation unless preserved by acidity or refrigeration. In contrast, fried foods, despite moderate moisture levels, remain susceptible due to near-neutral pH conditions.

Ash content plays a secondary role but provides insight into raw material purity and environmental contamination. Elevated ash values in certain samples may reflect variability in ingredient sourcing or exposure during processing (Mitu *et al*., 2026; Marshall, 2010)

Acidic fermented food matrices may selectively suppress several spoilage-associated bacteria while favoring acid-tolerant microbial communities, thereby altering predicted spoilage dynamics.

4.7 Limitations and Future Work

This study relied on physicochemical parameters as indirect indicators of microbial stability. While these provide strong predictive value, they do not replace direct microbiological enumeration. No direct microbial enumeration or pathogen identification was performed in this study.

Future studies should integrate microbial load analysis, including total viable count, coliform detection, and fungal profiling to validate spoilage risk predictions. Additionally, predictive modelling combining moisture, pH, storage time, and temperature exposure would improve shelf-life estimation accuracy (World Health Organization, 2022; Salamandane *et al*., 2023)

Furthermore, water activity (aw), storage temperature, and storage duration were not measured and may influence actual microbial behavior in food matrices.

5.0 Conclusion

This study evaluated the moisture content, ash content, and pH characteristics of selected Nigerian street-vended foods and examined their implications for predicted microbial stability and spoilage susceptibility. The results revealed substantial physicochemical variability among food categories, reflecting differences in formulation, processing methods, and environmental exposure during preparation and vending.

Fermented foods generally exhibited high moisture contents but comparatively lower predicted spoilage susceptibility due to their acidic pH values, whereas fried and bakery products were characterized by near-neutral pH conditions that may favor microbial persistence when combined with moderate moisture levels. Variations in ash content further suggested differences in ingredient composition and possible environmental influences associated with street-vending practices.

The findings demonstrate that spoilage susceptibility is influenced by the combined interaction of moisture availability and acidity rather than by any single physicochemical parameter. Foods exhibiting elevated moisture content together with near-neutral pH may present increased spoilage risk under ambient storage conditions, while acidic food matrices may provide a degree of protection against microbial proliferation despite high moisture levels.

Overall, the study highlights the value of physicochemical profiling as a rapid and cost-effective approach for preliminary assessment of food quality and inferred spoilage risk in resource-limited settings. These findings underscore the need for improved hygienic handling practices, enhanced storage conditions, and routine monitoring of street-vended foods to support food safety and public health protection. Future studies should integrate direct microbiological analyses and predictive modelling approaches to validate and strengthen physicochemical-based spoilage risk assessments.

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Author contributions

KSO (Kanayo Samuel Okonji) conceptualized and designed the study, conducted the literature review, developed the methodology, performed data analysis, interpreted the results, drafted the manuscript, revised the manuscript critically for important intellectual content, and approved the final version of the manuscript.

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Declaration of Generative AI and AI – Assisted technologies

The authors declare that ChatGPT (OpenAI) was used solely for language polishing and grammar refinement during the preparation of this manuscript. The scientific content, data interpretation, analysis, and conclusions were developed independently by the authors, who take full responsibility for the integrity of the work.

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Not applicable.

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