Street Vended Donkunu (Kenkey) and its Raw Sauce in Southwest Nigeria: A Plethora of Potential Pathogens and Source of Foodborne Illnesses

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Abstract: Street vended foods attract the populace because of their savory taste preferred by the indigenous public, and have contributed significantly to the maintenance of the food supply chain. Consumption of street food is significantly increasing due to a busy scheduled life. Donkunu and its complementary sauce is a Ghanaian delicacy that has been consumed in Nigeria over the years, but the safety status of the vended version is yet to be elucidated. This study assessed the microbiological safety of street-vended Donkunu, a Ghanaian delicacy, between February and March 2023. The researchers collected data from 149 questionnaires and 22 samples from five major markets. Enumeration of indicator organisms was done using standard microbiological procedures and identified using high throughput Illumina sequencing method. It was observed that the vendors had good food safety knowledge but poor practice and implementation. The majority of samples had a high microbial hazard according microbiological specifications for ready-to-eat foods of the United Kingdom Health Protection Agency. Similarly, metagenomics analysis reflected that there was a relative abundance of 63.4%, 18.17%, 0.045 and 8.43% of genus *Weisella*, *Lactobacillus*, *Vibro* and unclassified bacterial species in the Donkunu sauce. The presence of pathogens as well as the non-conformity of indicator organisms count to food safety standards reflected the poor food safety practices of the vendors and thus, suggests that the safety of street-vended Donkunu in Osogbo, Nigeria is relatively unsafe for consumption.

Key word: Street vended food, donkunu, microbial safety, food safety knowledge, food safety practice.

INTRODUCTION

According to the Food and Agricultural Organization (FAO), street-vended foods are "ready-to-eat (RTE) foods and beverages prepared and/or sold by vendors and hawkers, especially on the street and other similar public places, for consumption without further processing or preparation (FAO 2009; Meher *et al.,* 2022). Due to their attractiveness, affordability and convenience, street foods are growing in popularity among urbanites all over the world. This is especially true in many developing nations where they serve as a source of employment and income for poor urban residents (Soon, 2019). As a matter of practice, mobile vending, street food vendors operate their business in locations (Kwol *et al.,* 2020) that do not adhere to the minimum standards for food safety and hygiene. This perhaps buildup of excessive amounts of garbage and other wastes that act as a sanctuary for vermins, insects and animal pests (Choudhury *et al.,* 2011).

Public health is greatly endangered by the street food vendors' poverty, degree of illiteracy, and ignorance of appropriate food handling practices which is a major cause for concern (Sousa *et a*l., 2022). The microbiological quality of street food can have a big impact on foodborne infections (Hanashiro *et al.,* 2005; Al Mamun *et al.,* 2013) as the leading cause of disease and fatalities worldwide is food sold on the streets that may be contaminated by food pathogens (Choudhury *et al.,* 2011).

Ghanaian delicacy "Donkunu", and its raw sauce have been introduced to Nigeria and other West African countries for many years through immigration. To provide a balanced diet and make it deliciousfor consumption, the donkunu morsel is produced along with a sauce prepared with raw pepper fruits,

tomatoes, onions, seasoning, and fried fish (Obodai *et al.,* 2014). Despite the consumption of donkunu over the years in southwest Nigeria, there is a paucity of information about the microbiological safety of this street food and its sauce. Considering this, and other health implications this study investigated the microbial safety of the street-vended donkunu sauce sold on the streets of Osogbo, Nigeria as well as the knowledge, and practice of its vendors on food safety.

MATERIALS AND METHODS

Study area: A cross-sectional study was conducted in Osogbo, Nigeria, a city constrained to the latitudes 7º6'N and 7º15'N and the longitudes 3º 17'E and 3º 25'E with a population of around 771,515 (World Population Review, 2023) by 2023. It is situated in Nigeria's South-West region. Major markets in the city, including Igbona, Woru, Owode Ede, Ota Efun, and Oja Oba, serve as sample collection area. The spatial representation of the markets constructed with ArcPRO software is presented in Figure 1.

Study design: The study assessed food safety practices and knowledge among donkunu street sellers in Osogbo's main markets and its surroundings between January and March 2023 using 149 structured questionnaires and 22 samples of sauce and donkunu. Vendors were identified through the snowball approach (Johnson, 2014) and given full disclosure and consent for research purposes.

The study assessed food safety knowledge and practices among vendors using a questionnaire adapted from Wenrich *et al.* (2003), focusing on socio-demographic, knowledge, and practices sections.

Study variables: The study analyzed food safety practices and knowledge as dependent variables, while socio-demographic, sanitation, and hygiene-related factors were independent variables.

Sample collection: About 100 g each of donkunu and sauce samples were collected from vendors (mobile and stationary) at five markets, labeled, sealed, and transported in under cold to a laboratory for processing within 4 hours.

Microbiological analysis: The quantitative microbial analysis of the collected samples was analyzed using the pour plate enumeration technique following serial dilution as described by Adeyemi *et al.* (2023). The dilutions were plated on MacConkey agar, Eosin methylene blue agar, and Salmonella-Shigella agar (Hi-Media, India) for total coliform, *Escherichia coli*, *Salmonella* spp., and *Shigella* spp. counts respectively. All inoculated plates were incubated at 37°C for 48 hours.

Next-generation sequencing of bacterial community in donkunu sauce: Donkunu sauce samples were pooled to estimate bacterial community, as reported by using Ray *et al.* (2013). Genomic DNA was obtained from Ezekiel *et al.* (2019) method, and the estimated bacteria population was examined utilizing high throughput sequencing of the partial 16S rRNA gene hypervariable region V3-V4 on the IlluminaMiSeq sequencer (Illumina Inc., CA, USA) as described Ezekiel *et al.,* (2019).

Assessment of safety status: The samples' microbiological risk status was determined by comparing the microbial data to safety standards established by the UK Health Protection Agency (HPA, 2009).

Data analysis: Statistical analysis was done using IBM SPSS version 21.0. Chi-square was used to identify the association between the dependent and independent variables. The total coliform count was expressed as Log10 CFU/g/ml. Bacteria identification was done using QIIME2 (version 2).

RESULTS

Figure 2 presents the socio demographic data of the respondents. The respondents are mainly female comprising of married (68.5%), single (30.2%), and divorced (1.3%) women. The majority of the respondents are Christians (65.1%) with few Muslims (34.2%) and Traditionalists (7%) being Nigerians (88.6%), Ghanaians (7.4%),

and Togolese (4.0%) by Nationality. Furthermore, most (46.4%) of the respondents are literates having post-secondary school education. The ages of the respondents varied between ≤ 29 years (32.9 %); 30 - 39 years (43.6 %) and ≥ 45 years (23.5 %).

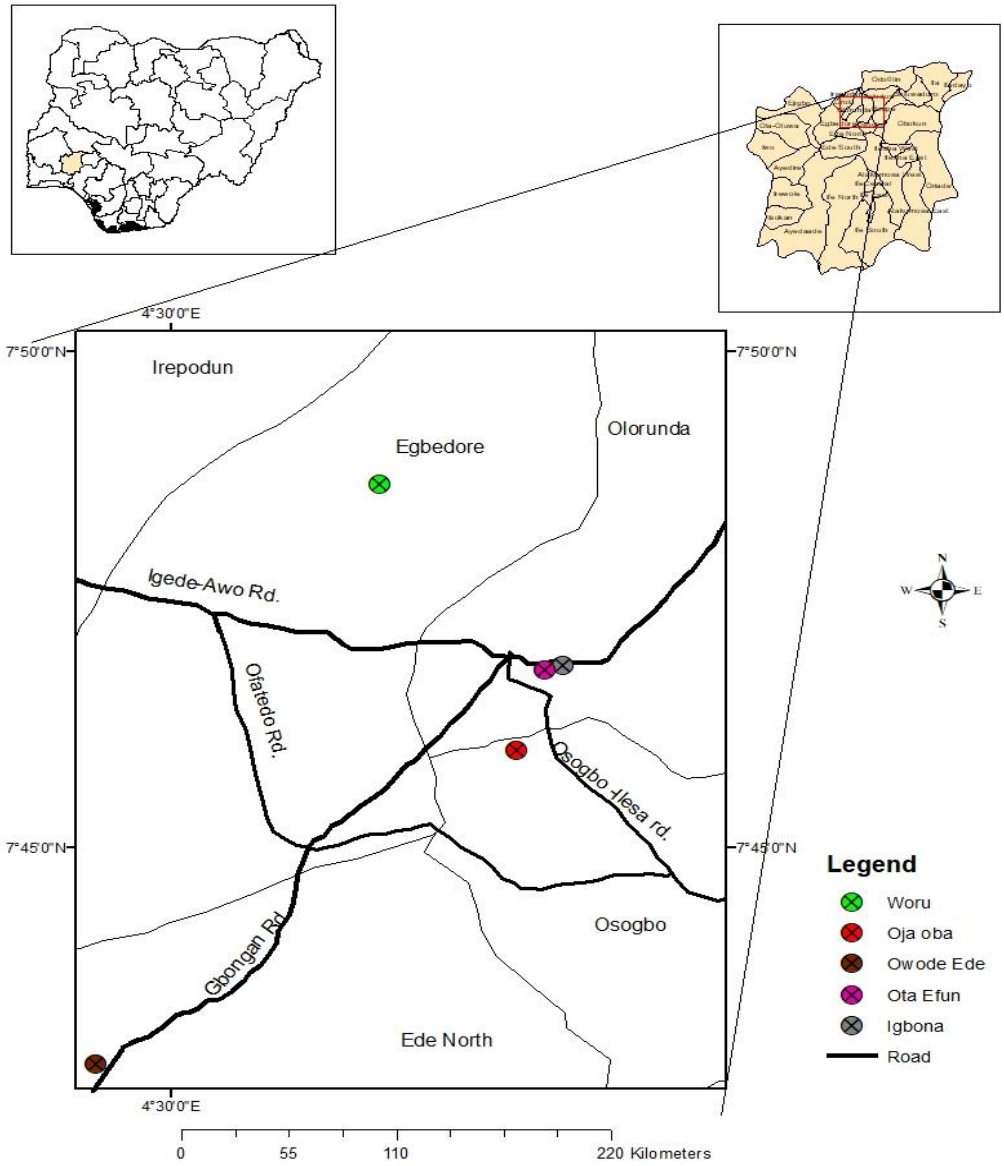

Figure 1: Spatial representation of the sample locations

Table 1: Frequency distribution, correlation of respondent's food safety knowledge, and practice

Variables	Knowledge		Practice		p-value
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
Poor (0-25%)	1	0.7	0	0	
Fair (26-50%)	3	2.0	27	18.1	
Good (51-75%)	19	12.8	62	41.6	0.14
Excellent (76-100%)	126	84.6	60	40.3	
Total	149	100.0	149	100.0	

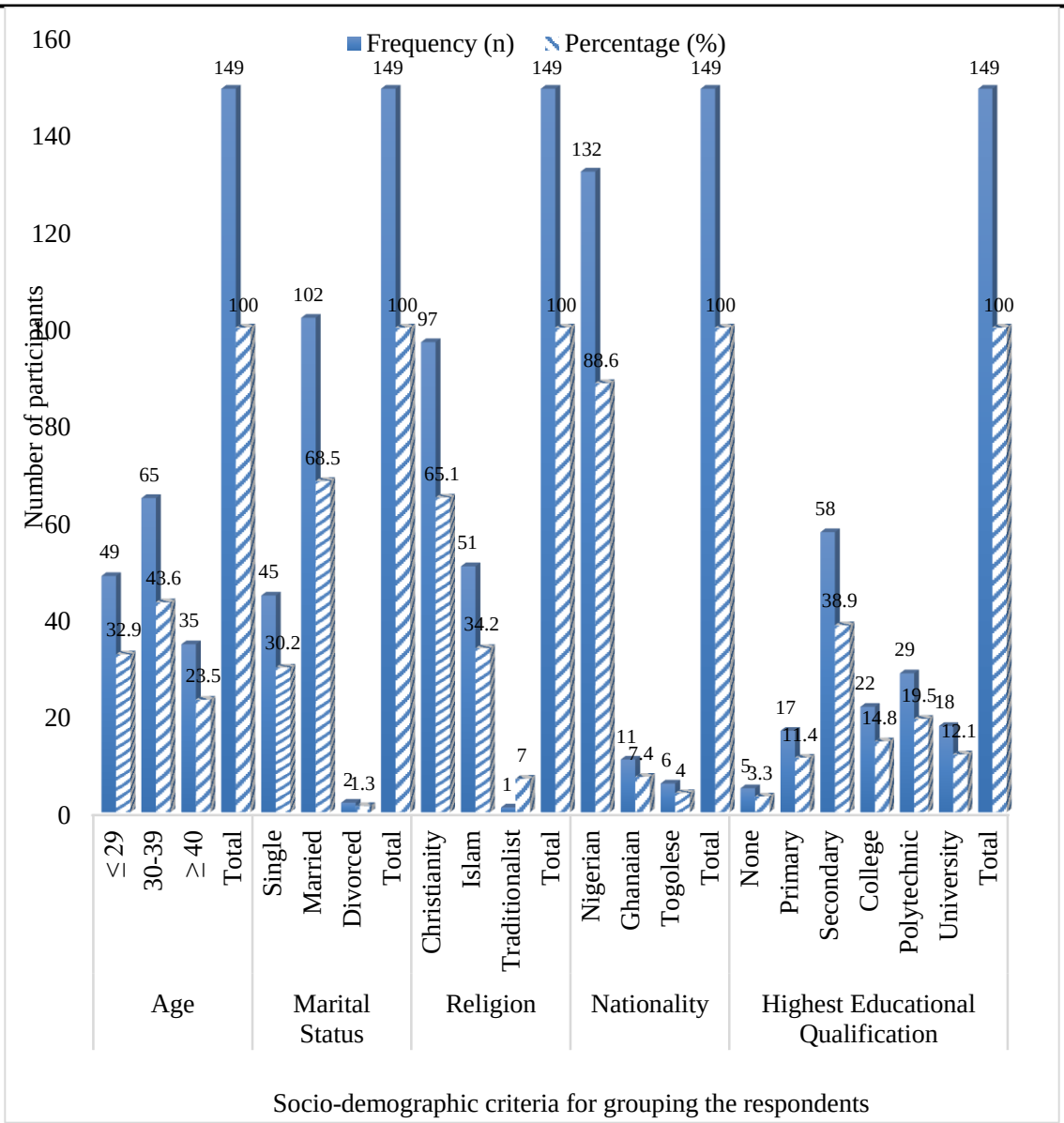

Figure 2: The socio-economic and demographic data of the respondent

Table 1 shows the food safety knowledge and practice of the food vendor. The study found that 12.8% and 84.6% of interviewed respondents had good and excellent food safety knowledge, while 41.6% and 40.3% had good and excellent practices. Table 2 presents the correlation between food safety knowledge and profile of the respondents, while Table 3 presents the correlation between food safety practice and the assessed respondent's profile. The study showed no significant correlation between food safety knowledge and respondents' profiles, but religion, monthly income, education level, and vendor type had a significant impact. Most respondents had less than a decade of experience, with mobile vendors being the most common. The study analyzed 22 donkunu samples from street vendors for foodborne pathogens, including common bacteria like *Escherichia coli*, *Shigella* spp., and *Salmonella* spp. *Salmonella* and *Shigella* colonies were found in 63.3 and 72.7% of donkunu samples, while in 45.5% and 72.7% of complementary sauce samples respectively (Table 4). Table 5 reflects that the vending option of the respondent significantly affected the vending contamination with indicator organisms

assessed. The study revealed the bacterial community in raw donkunu sauce, identifying 2,509 OTU and 5,015 bacteria, with firmicutes dominating at 99.72%, followed by Proteobacteria, Actinobacteria, Cyanobacteria, and Acidobacteriota (Figure 3). The genus classification of the bacterial present reflects the presence of *Weisella*, *Lactobacillus*, *Vibro* as well as unclassified bacterial specie (Table 6).

Table 2: Correlation between food safety knowledge and profile of the respondent

Criteria	Classification	Food Safety Knowledge					
		Poor	Fair	Good	Excellent	Total	p-value
Age	≤ 29	0 (0.0%)	1 (2.0%)	2 (4.1%)	46 (93.8%)	49 (100%)	0.33
	30-39	0 (0.0%)	2 (3.1%)	10 (15.3%)	53 (81.5%)	65 (100%)	
	>40	1 (2.6%)	3 (7.8%)	7 (18.4%)	27 (71.0%)	38 (100%)	
Gender	Female	1 (0.7%)	3(2.0%)	19 (12.8%)	126 (84.6%)	149 (100%)	NA
Marital status	Single	0 (0.0%)	0 (0.0%)	3 (6.7%)	42 (93.3%)	45 (100%)	0.57
	Married	1 (1.0%)	3 (2.9%)	16 (15.7%)	82 (80.4%)	102 (100%)	
	Divorced	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100%)	2 (100%)	
Religion	Christianity	1 (1.0%)	2 (2.1%)	15(15.5%)	79 (81.4%)	97 (100%)	1.00
	Islam	0 (0.0%)	1 (2.0%)	4 (7.8%)	46 (90.2%)	51 (100%)	
	Traditionalist	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	1 (100%)	
Nationality	Nigerian	1 (0.8%)	2 (1.5%)	17 (12.9%)	112 (84.8%)	132 (100%)	0.76
	Ghanaian	0 (0.0%)	1 (9.1%)	1 (9.1%)	9 (81.8%)	11 (100%)	
	Togolese	0 (0.0%)	0 (0%)	1 (16.7%)	5 (83.3%)	6 (100%)	
Education level	None	0 (0.0%)	1 (20.0%)	1 (20.0%)	3 (60.0%)	5 (100%)	0.08
	Primary	0 (0.0%)	1 (5.9%)	4 (23.5%)	4 (70.6%)	17 (100%)	
	Secondary	1 (1.7%)	0 (0%)	5 (8.6%)	52 (49.0%)	58 (100%)	
	Tertiary	0 (0.0%)	1 (1.4%)	9 (13.0%)	59 (85.5%)	69 (100%)	
Duration of experience(years)	< 5	0 (0.0%)	2 (2.7%)	12 (16.4%)	59 (46.8%)	73 (100%)	0.78
	6-10	1 (1.9%)	1 (1.9%)	5 (9.6%)	45 (86.5%)	52 (100%)	
	11-15	0 (0.0%)	0 (0%)	1 (5.0%)	19 (95.0%)	20 (100%)	
	>16	0 (0.0%)	0 (0%)	1 (25.0%)	3 (75.0%)	4 (100.0%)	
Monthly income (thousands (₦)	10- 20	1 (1.3%)	1 (1.3%)	12 (15.2%)	65 (82.3%)	79 (100%)	0.60
	20-30	0 (0.0%)	2 (4.2%)	6 (12.5%)	40 (83.3%)	48 (100%)	
	>30	0 (0.0%)	0 (0.0%)	1 (4.5%)	21 (95.5%)	22 (100%)	
Food Safety training	Yes	0 (0.0%)	2 (2.4%)	2 (17.9%)	67 (79.8%)	84 (100%)	0.12
	No	1 (1.5%)	1 (1.5%)	4 (6.2%)	59 (90.8%)	65 (100%)	
Type of vendor	Mobile	0 (0%)	21 (10.0%)	38 (42.7%)	30 (33.7%)	89 (100%)	0.48
	Stationary	0 (0%)	6 (10.0%)	24 (40.0%)	30 (24.2%)	60 (100%)	

Table 3: Correlation between food safety practice and profile of the respondent

Criteria	Classification	Food Safety Practice					
		Poor	Fair	Good	Excellent	Total	p-value
Age	≤ 29	0 (0%)	8 (16.3%)	18 (36.7%)	23 (46.9%)	49 (100%)	0.15
	30-39	0 (0%)	8 (12.9%)	31 (47.6%)	26 (40.0%)	65 (100%)	
	>40	0 (0%)	11 (31.4%)	13 (37.1%)	11 (31.4%)	35 (100%)	
Gender	Female	0 (0%)	27 (18.1%)	62 (41.6%)	60 (40.3%)	149 (100%)	NA
Marital status	Single	0 (0%)	6 (13.3%)	19 (42.2%)	20 (44.4%)	45 (100%)	0.57
	Married	0 (0%)	20 (19.6%)	42 (41.2%)	40 (39.2%)	102 (100%)	
	Divorced	0 (0%)	1 (50%)	1 (50%)	0	2 (100%)	
Religion	Christianity	0 (0%)	15 (15.5%)	50(51.5%)	32 (33.0%)	97 (100%)	<0.01
	Islam	0 (0%)	11 (21.6%)	12 (23.5%)	28 (54.9%)	51 (100%)	
	Traditionalist	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)	
Nationality	Nigerian	0 (0%)	23 (17.4%)	52 (39.4%)	57 (43.2%)	132 (100%)	0.16
	Ghanaian	0 (0%)	2 (18.2%)	8 (72.7%	1 (9.1%)	11 (100%)	
	Togolese	0 (0%)	2 (33.3%)	2 (33.3%)	2 (33.3%)	6 (100%)	
Education level	None	0 (0%)	4 (80.0%)	1 (20.0%)	0 (0.0%)	5 (100%)	<0.01
	Primary	0 (0%)	5 (29.4%)	8 (47.1%)	4 (23.5%)	17 (100%)	
	Secondary	0 (0%)	11 (19.0	23 (39.7%)	24 (41.4%)	58 (100%)	
	Tertiary	0 (0%)	7 (10.1%)	30 (43.5%)	32 (46.4%)	69 (100%)	
Duration of experience(years)	< 5	0 (0%)	16 (21.9%)	33 (45.2%)	24 (32.9%)	73 (100%)	0.39
	6-10	0 (0%)	6 (11.5%)	22 (42.3%)	24 (46.2%)	52 (100%)	
	11-15	0 (0%)	4 (20.0%)	5 (25.0%)	11 (55.0%)	20 (100%)	
	>16	0 (0%)	1 (25.0%)	2 (50.0%)	1 (25.0%)	4 (100.0%)	
Monthly income (thousands (₦)	10- 20	0 (0%)	20 (25.3%)	36 (45.6%)	23 (29.1%)	79 (100%)	0.02
	20-30	0 (0%)	6 (12.5%)	17 (35.4%)	25 (52.1%)	48 (100%)	
	>30	0 (0%)	1 (4.5%)	9 (40.9%)	12 (54.5%)	22 (100%)	
Food Safety training	Yes	0 (0%)	16 (19.0%)	41 (48.8%)	27 (32.1%)	84 (100%)	0.06
	No	0 (0%)	11 (11.8%)	21 (32.3%)	33 (50.8%)	65 (100%)	
Type of vendor	Mobile	1(1.1%)	2 (2.2%)	17 (19.1%)	69 (77.5%)	89 (100%)	0.03
	Stationary	0 (0.0%)	6 (10.0%)	24 (40.0%)	30 (24.2%)	60 (100%)	

Table 4: Microbial safety status of the Donkunu and its complementary raw sauce according to the UK Health Protection Agency microbiological specifications

Organism	Donkunu		Donkunu sauce	
	ND	D	ND	D
Coliform (log CFU/g)	0 (0.0%)	22 (100.0%)	0 (0.00%)	22 (100.0%)
Salmonella spp. (log CFU/25g)	8 (36.4%)	14 (63.6%)	6 (27.3%)	16 (72.7%)
Shigella spp. (log CFU/25 g)	6 (27.3%)	16 (72.7%)	12 (54.5%)	10 (45.5%)
Escherichia coli (log CFU/g)	0 (0.0%)	22 (100.0%)	0 (0.0%)	22 (100.0%)

ND-Not detected; D- Detected, CFU- colony forming unit

Table 5: Effect of vending type on the safety status of donkunu and its complementary stew

Food type		Coliforms (log CFU/g)	*Escherichia coli* (log CFU/25g)	*Shigella* spp. (log CFU/25g)	*Salmonella spp.* (log CFU/25g)
Donkunu	Mobile	0.09 ± 0.61	1.00 ± 0.62	0.36 ± 0.58	0.27 ± 0.70
	Stationary	0.09 ± 0.61	1.00 ± 0.62	0.36 ± 0.58	0.27 ± 0.70
	t- value	0.70	7.60	2.94	1.82
	p-value	0.49	< 0.01	0.01	0.08
Donkunu Sauce	Mobile	0.72 ± 0.46	0.64 ± 0.58	0.27 ± 0.63	0.00 ± 0.76
	Stationary	0.72 ± 0.46	0.64 ± 0.58	0.27 ± 0.63	0.00 ± 0.76
	t- value	7.48	5.12	2.03	< 0.01
	p-value	< 0.01	< 0.01	0.06	1.00

CFU- colony forming unit

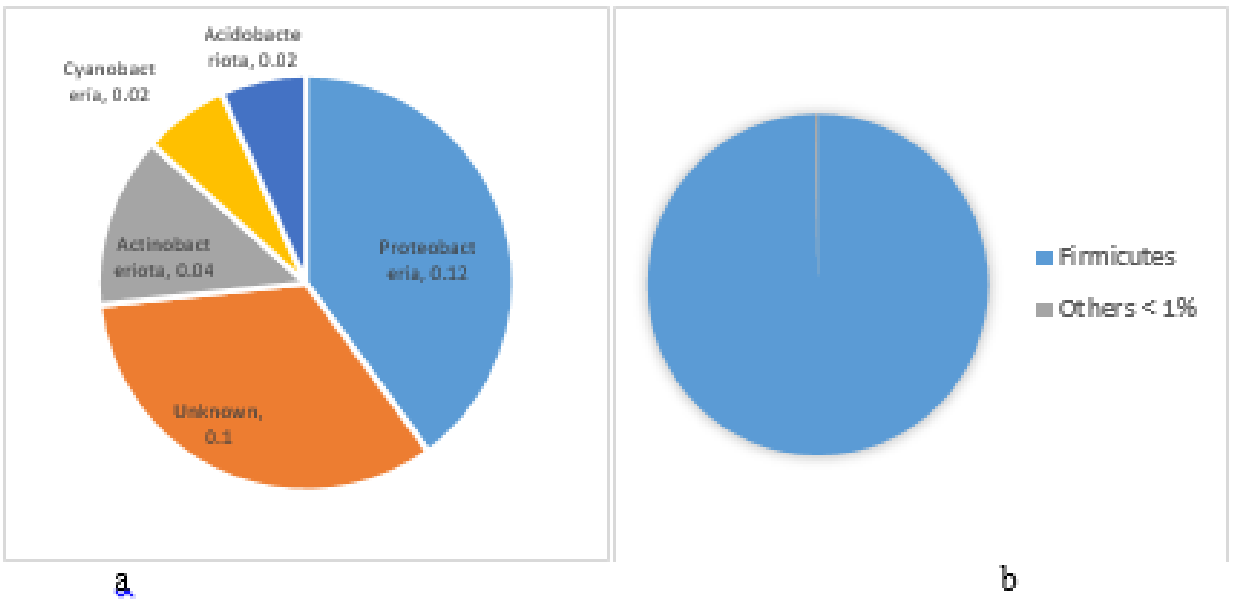

Figure 3: Phylum classification of bacteria in Donkunu Sauce; a- relative abundance of less than 1%, b- relative abundance of greater than 1%

Table 6: Classification and proportion of the bacterial community in the Donkunu sauce

Genus	%	Species	%
Weissella	63.41	*Weissella – Weissellacibaria*	51.43
Lactobacillus	18.17	Unknown	38.52
Unknown	8.43	*Weissella – Weissellaconfusa*	5.82
Leuconostoc	8.32	*Lactobacillus – Lactobacillus* sp.	1.42
Pediococcus	1.34	*Pediococcus – Pediococcusacidilactici*	0.56
Staphylococcus	0.06	*Lactobacillus* – uncultured Lactobacillaceae	0.46
Bacillus	0.06	*Pediococcus* – uncultured Bacillus	0.46
Vibrio	0.04	*Weissella – Weissellaparamesenteroides*	0.38
Acetobacter	0.04	*Lactobacillus* - uncultured Bacillus	0.28
Acidocella	0.02	*Leuconostoc - Leuconostocpseudomesenteroides*	0.22
Paenibacillus	0.02	*Lactobacillus - Lactobacillus brevis*	0.10
Streptococcus	0.02	*Leuconostoc* - uncultured bacterium	0.10
Gastranaerophilales	0.02	*Staphylococcus – Staphylococcus simulans*	0.06
Lachnospiraceae UCG	0.02	*Weissella* – uncultured bacterium	0.04
Christensenellaceae R	0.02	*Lactobacillus – Lactobacillus oris*	0.02
Uncultured species	0.02	*Leuconostoc – Leuconostocgarlicum*	0.02
		Pediococcus – Pediococcuspentosaceus	0.02
		Lachnospiraceae – UCG uncultured bacterium	0.02
		Christensenellaceae - R uncultured bacterium	0.02

DISCUSSION

Street foods, a popular public dining option worldwide, especially developing countries provide fast meals and snacks from dawn to dusk, but safety concerns persist (Mamunand Turin, 2016). Donkunu, a Ghanaian staple food, also known as kenkey was introduced to neighbouring West African countries like Nigeria by immigrants. The labourious African dish takes 4-6 days to prepare (Obodai *et al.,* 2014). Commonly served with sauce prepared from ground fresh pepper, tomatoes, onions and complemented with fried fish. The uniqueness in the delicacy, coupled with industrialization and urbanization on home-made meals has encouraged the exploration of street vendors by its consumers of various ranks and titles southwestern Nigeria towns.

This study assessed demographic characteristics and vendor knowledge and practice in food safety conditions and practices, focusing on factors like gender, age, religion, nationality, literacy, and food safety training, using research-based questionnaires. According to the study, African women are more naturally active in small businesses such as street food vending than males due to restricted employment alternatives in developing nations. This is consistent with earlier findings in Cameroon (Acho-Chi, 2002), Botswana (Ohiokpehai, 2003), Kenya (Muinde and Kuria, 2005), Nigeria (Madaki and Bavorova, 2019), Ethiopia (Azanaw *et al*., 2022), and South Africa (Nkosi and Tabit, 2021), but differs from Guwahati (Choudhury *et al.,* 2011) and Bangladesh (Meher *et al*., 2022). The nationality of the respondents reflects the integration of the delicacy (donkunu) among other West African countries. The religion of the respondents significantly influenced their food safety practices but, did not influence their food safety knowledge. Between 1957 and 1969, Nigerians migrated from Ghana, influencing the consumption of Donkunu by respondents with ages over 45-year-old. This study shows youth engagement in street vended food businesses, indicating successful skill transfer as reported by Adane *et al.* (2018); and Madaki and Bavorova (2019). However, age does not significantly influence food safety knowledge and practice, unlike religion. The study found that most participants were literate. On the contrary, earlier research in Ethiopia (Adane *et al.,* 2018) and Uganda (Muyanja *et al.,* 2011), showed lower levels of education compared

to the present study. Food safety knowledge can be learned through educational programs and training courses (Ansari *et al*., 2010), but the literacy level of vendors in this did not significantly impact their practices. It is important to note that Osun state Government-organized food safety training sessions during school recruitment which could contribute to the vendor's food safety knowledge. However, the acquired food safety knowledge do not significantly influence food safety practices assessed in this study suggesting that food safety knowledge alone does not guarantee positive adjustments. The percentages of respondents with good food safety knowledge and practice in this study are higher than previous studies (Sani *et al.,* 2014; Rahman *et al.,* 2016; Adane *et al.,* 2018), possibly due to socio-demographic factors, sample size, seasonal activity, and flexible location. Although there is no significant correlation between the food safey knowledge and practice of the respondent at $p<0.05$ (Table 1). Furthermore, the disparity in food safety knowledge among Donkunu vendors in Osogbo, Nigeria could be associated with their low income, with 80% earning less than the Nigerian government's minimum wage and 14.8% earning more than N30, 000. Low-income households often engage in unsafe food safety practices due to financial constraints to purchase necessary cleaning solvents. Income increases improve food safety practices, through access to sanitary materials and medical attention. This coupled with high inflation rates in the economy, significantly influences food safety practices observed. This supports previous research on low-income households Liu (2020). The vending option significantly impacts food safety practices of respondents in this study with stationary vendors having better access to clean water for cleaning. Mobile vendors struggle with accessing clean water due to mobility and inconveniences, limiting their frequency of hand washing during vending operations and after toilet use. The detection of *Salmonella* spp*.*, *Escherichia coli*, and *Shigella* spp. in 25 grams of sample UK's ready-to-eat food guidelines show high microbial risk raising safety concerns as vendors may harbor these pathogens and transmit them to consumers. Contamination in raw complementary sauce and donkunu morsel is likely due to minimal heat treatment and post-processing factors respectively. This aligns with previous studies with over half of respondents with poor food safety practices. Further-more, vendors adulterate sauces by adding cooked stew, potentially reducing pathogenic load. Vendor status significantly influences contamination by *Escherichia coli* and *Shigella* spp., with limited access to clean water. Fresh pepper, tomatoes, onions, and a few spices like turmeric and ginger are combined with monosodium glutamate and salt to make the raw donkunu sauce. Freshly cut vegetables are known to harbour considerable populations of bacteria, including pathogens like *Salmonella* sp*p., E. coli*, and *Listeria monocytogenes* (Oyinlola *et al*., 2017) but the selected spices too have antimicrobial properties (Liu *et al*., 2017). The culture independent method, employed in this investigation identified harmful Gram-negative bacteria in the phylum Proteobacteria, including *Vibrio*, *Acetobacter*, and uncultured bacteria. The presence of *Vibro* is of great concern for consumer's health. It can be assumed that *Salmonella* spp*.*, *Shigella* spp., and *Escherichia coli* which were enumerated using culture dependent method were included among the unidentified members of the phyla Proteobacteria. Firmicutes, including *Leuconostoc, Pediococcus, Staphylococcus, Bacillus, Lactobacillus, Weissella*, and unclassified genera, were also identified. Over 80% of Firmicutes are lactic acid bacteria, potentially inhibiting pathogenic growth. Firmicutes phylum, with their competitive advantage against pathogenic microorganisms, are ideal for developing bioprotective agents for fresh fruits and vegetables. They can also be used in food biopreservation to inhibit pathogenic microorganisms. Studies show that non-pathogenic microbes can interact with and inhibit microbial pathogens on fruit surfaces

(Teplitski *et al.*, 2011). The presence of Firmicutes members in Donkunu sauce might influenced the growth of pathogenic organisms. However, fermenting organisms in the sauce vegetable signifies food spoilage which can result to undesirable organoleptic properties. Fermenting organisms in produce are influenced by farming and storage conditions, according to Gram *et al.* (2002). Furthermore, this study identifies other members of the phylum Firmicutes- *Bacillus* and *Staphylococcus*- whose members can be pathogenic or non-pathogenic. Staphylococcus aureus is pathogenic and causes infectious diseases (Abdulreesh and Organji, 2011), while *Staphylococcal saprophyticus* (Rosenstein and Götz, 2012) is a non-pathogenic and beneficial in fermented meat. It is important to note that the migration of antibiotic resistance genes and virulence determinants between pathogenic and non-pathogenic staphylococcal species (Dionisio *et al.*, 2023) is a significant public health concern. The relative abundance of the members of the phyla Firmicutes and Proteobacteria in the sauce aligns with findings of Nuraida (2015), Boumba *et al*. (2021), who stated that bacterial population in peppers is typically composed of the phyla Firmicutes and Proteobacteria. Furthermore, the small relative abundance of the phylum Actinobacteria is consistent with the findings of Boumba *et al.* (2021).

CONCLUSION

The study assessed the microbial safety of donkunu and its sauce, assessing food safety knowledge and practice. It found that while the knowledge is good, it does not translate into good practice, with high microbial risk identified in the street vended donkunu and its raw sauce regularly consumed in the study area.

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