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BACTERIOLOGICAL QUALITY ASSESSMENT OF READY-TO-EAT HAWKED SUYA IN DUTSE URBAN, NORTHWEST NIGERIA

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Suya is a street-hawked food that offers a source of the nourishing menu for its consumers. In this study, the quality and safety of street hawked ready-to-eat suya in Dutse urban was assessed. Twenty skewers of suya were sampled from four sampling points (Hakimi Street, Yelwawa, Takuradua and Mobile base) where it is mostly sold. At each sampling point, five skewers of suya were obtained randomly from the suya vendors in sterile containers that were labeled A to T. Samples were immediately taken to the laboratory where standard methods were employed for the bacteriological assay. The total viable count (TVC) showed that the sample G (1.96×10^7 CFU/g) collected from Yelwawa had the highest load while sample P (8.60×10^6 CFU/g) collected from Takuradua recorded the lowest. *Bacillus* spp., *Staphylococcus* spp., *Escherichia coli* and *Streptococcus* spp. were detected in the samples. Across the sampling points, percentage of occurrence of bacteria isolated was highest for *Escherichia coli* (40%) and least for *Bacillus* spp. (10%). It can be concluded that all the sampled suya assayed in this study recorded bacteriological contaminants. Some of the bacteria isolated in the suya samples can potentially constitute a public health issue as their presence can cause food poisoning and food-borne diseases. Therefore, it is recommended that the producers of street vended suya should follow proper food safety measures during preparation to improve the food quality as well as to reduce imminent public health crisis upon its consumption.

Keywords: Suya, ready-to-eat, bacteriological contaminants, total viable count and public health.

INTRODUCTION

Suya is a street-vended food which provides a source of inexpensive, convenient and often nutritious menu for cities, urban and rural areas; a major source of income for a vast number of people and creates enough opportunities for self-employment (1). Today, traditional processed meat products are consumed in various nations, including the delicacy known as suya (2). These authors defined suya as a traditional barbecue, smoked or roasted obtained from thinly sliced boneless meat and marinated with various spices such as clove, ginger, pepper, salt, peanut cake, vegetable oil as well as food additives and flavorings. Suya is eaten and enjoyed as a delicacy in West Africa (3).

The origin of suya can be linked with the Hausas in Northern Nigeria, and other countries in its environs like Chad, Sudan and Niger (4). Indigenous Fulani and Hausa people that are domiciled in Northern Nigeria originated the meat delicacy as they are involved in cattle rearing and husbandry (5). Ready-to-eat meat products such as suya, kilishi and balangu have long been known for its high nutrients composition and are hence eaten by many people worldwide. Majority of the world's population now consumes these food products. In the past, people have expressed worry about the role of meat and meat products in food poisoning but available records show that more than 74% of cases of food poisoning worldwide are due to meat dishes (6). Generally, meat is excellent in supplying high-quality protein, vitamins and minerals salt. In the world today, suya is eaten in different countries, among which is the meat delicacy (7). It has become very popular as a street delicacy in several countries, particularly those in West Africa (4).

Some authors (8,4) have reported cases of ill health effects attributable to the consumption of suya. This is a clear indication that consumption of this ready-to-eat food item can constitute a serious public health threat. Owing to the array of microorganisms detected in the suya samples assayed in Southwest Nigeria, its consumption may lead to a public health issue (9). Equally, a study conducted on the quality of suya sold in Makurdi, northern Nigeria revealed considerable level of faecal coliforms while another study detected *Bacillus cereus*, *Staphylococcus aureus*, *Salmonella* species and some pathogenic moulds in suya samples assayed in their study area (4, 10). Variations in the flavour, taste and microbial contaminants attributable to suya have got strong relationship with its production mode (8). Bacterial contaminants commonly detected on suya are those that have got the capability of producing lactic acid (11). Based on the information depicted above, this study aimed to assess the quality of ready-to-eat suya hawked and sold to consumers in Dutse urban.

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MATERIALS AND METHODS

Sample Collection. The suya samples were collected in Dutse urban. Dutse is the capital city of Jigawa state, Northwest Nigeria. Dutse urban lies geographically at a latitude of 11º42′8.46′′N and a longitude of 9º20′2.46′′E (12). The collected suya samples were prepared for analysis according to the procedure described by (6). Twenty skewers of suya (13) were sampled from four sampling points (Hakimi street, Yelwawa, Takuradua and Mobile Base) where it is mostly sold in Dutse urban. At each sampling point, five skewers of suya were obtained randomly from the suya vendors in sterile containers that were labelled A to T. Samples were enfolded in sterile Aluminium foil and immediately taken to the laboratory where standard methods were employed for the bacteriological assay (14).

Sample Preparation. Suya pieces from each sample were removed and aseptically cut into thin smaller pieces using sterile knife and mashed in a sterile mortar and pestle. One gram of the mashed suya was weighed and serially diluted using 1 ml from stock homogenate and 9 ml of distilled water (7). This was carried out to obtain a discrete colony.

Determination of Total Viable Count of the Sampled Suya. The pour plate method was employed for the determination of the total viable count as described elsewhere (15). A five-fold serial dilution was done for the suya samples in appropriate dilution tubes. Specifically, 0.1 ml of the homogenized sample was taken from 10^{-5} fold dilution and dispensed in sterile nutrient agar plates. It was then allowed to cool down and solidify. Afterward, plates were incubated at 37°C for 24 hours. Plates which did not show visible colonies after 24 hours were left for an additional 48 hours. Discrete colonies were purified by sub-culturing into nutrient agar plates and were subsequently identified using standard methods (7).

Plate Count. Serial dilutions of the sampled suya were made with distilled water. It was then cultivated on sterile nutrient agar in petri dishes which were sealed and incubated. As outlined by other researchers, one set of the petri dishes was subjected to incubation at 22°C for 24 hours and a second set at 37°C for 24 hours (8). After respective incubation periods, the bacterial colonies were counted visually.

Determination of Bacterial Counts. At the end of the incubation periods, the counts for each plate were done and then expressed as colony-forming unit per gram (CFU/g) of the sample. It was achieved by dividing the plate into four and then colonies were counted for each side. The number of colonies depends on their size: typically from 30 to 300 is appropriate on a standard 10 cm petri dish.

CFU/g is mathematically expressed as:

CFU/g = (Number of colonies × Dilution factor)/Amount of agar plated

Isolation of Bacteria from the Suya Samples. MacConkey agar was used for the isolation of *Escherichia coli* while other bacteria that might be present in the sampled suya were isolated using nutrient agar. The media were prepared according to the instructions of the manufacturer (HiMedia Laboratories Pvt Ltd, India). Bacterial isolation was done following the procedure reported by Asime et. al., 2020 (16).

Identification of Bacterial Isolates. Characterization and identification of the bacterial isolates were achieved by initial morphological examination of the bacterial colonies on the MacConkey and nutrient agar plates (macroscopically) for colonial appearance, size, elevation, form, edge, consistency, colour, odour, opacity, hemolysis and pigmentation hence results were recorded (7). Gram staining procedure was employed to differentiate between gram-positive bacterial isolates and gram-negative bacterial isolates (17). Subsequently, biochemical tests such as catalase, coagulase, indole, methyl red, vogesproskaeur, motility, glucose, oxidase, sucrose and citrate utilization were conducted to identify the bacterial isolates (18, 19, 20).

Data Analyses. Descriptive statistics was employed to summarize results recorded from the total viable counts (TVC). Results generated from the TVC of the sampled suya in all the sampling points were compared with allowable limits as described in the Microbiological Guidelines (21). One way ANOVA was employed to establish significant difference between the bacterial loads obtained across the sampling points.

RESULTS AND DISCUSSION

The results of sampled suya from hawkers who move from one place to another in order to sell their products are presented in Tables 1, 2, 3 and 4. During sampling, it was evident that the ready-to-eat suya sampled from the hawkers was not well covered and contained few dust particles. It can be observed from the results presented in Tables 1-4 that contamination of suya with bacteria cut across all the samples collected from all the Vendors. Specifically, sample A (1.30×10^7 CFU/g) recorded the highest total viable count (TVC) while sample E (9.20×10^6 CFU/g) recorded the lowest TVC in the suya samples collected in Hakimi street (Table 1), According to the Microbiological guidelines (21), samples A, B and C assayed in Hakimi street were not satisfactory for human consumption while samples D and E fell in the borderline. Sample G (1.96×10^7 CFU/g) recorded the highest TVC while sample J (1.16×107 CFU/g) recorded the lowest TVC in the suya samples collected in Yelwawa (Table 2).

We observed that all the samples were unsatisfactory going by the standards set by Centre for food safety standards of Hong Kong (21). Sample L (1.62×10^7 CFU/g) recorded the highest TVC while sample M (8.60×10^6 CFU/g) recorded the lowest TVC in the suya samples collected in Mobile Base (Table 3). It can be deduced that samples K, L and O were unsatisfactory while samples M and N were on the borderline (20). However, sample T (1.70×10^7 CFU/g) recorded the highest TVC while sample P (8.60×10^6 CFU/g) recorded the lowest TVC in the suya samples collected in Takuradua (Table 4). In reference to the Microbiological Guidelines (21), samples Q, R. S and T were unsatisfactory while sample P was on the borderline. However, it can be observed that there was no significant difference ($p>0.05$) between the bacterial loads obtained across all the sampling points (Table 5). The results obtained in this study are in agreement with the other reports on the viable bacterial contaminants obtained on hawked suya in their respective study areas (4, 7, 9). Again, the results obtained in this study are different from the other reports on the detection of bacterial contaminants on the ready-to-eat vegetables and Beske (fried soy cake) assayed in their respective study areas (22, 23).

The colonial attributes of the bacterial isolates which were obtained on culture media are depicted in Table 6. It can be observed that samples C, D, E, M, S, H, I and Q appeared in creamy colonies on nutrient agar as well as appearing in pink colonies on MacConkey agar (Table 6). Samples A and O equally appeared in creamy white colonies on nutrient agar but recorded no growth on MacConkey agar (Table 6).

However, samples B, J, F, P, K and R appeared in milky colonies on nutrient agar but recorded no growth on MacConkey agar (Table 6). Results of the gram staining done to differentiate between gram-positive and negative-bacteria amongst the bacterial isolates are presented in Table 6. It can be observed that four (4) distinct morphological characteristics; gram positive in rod shape, gram positive cocci in cluster, gram positive cocci in chain and gram-negative in rod shape were recorded under the microscope (Table 6).

The results of the various biochemical characterization tests conducted on the bacterial isolates with a view to identifying the possible bacteria inherently found in the sampled ready to eat suya are presented in Table 7. Having conducted various biochemical characterization tests, it can be observed that the bacterial isolates; gram positive rods, gram-positive cocci in clusters, gram negative rods shape and gram-positive cocci in chains were identified as *Bacillus* spp., *Staphylococcus* spp., *Escherichia coli* and *Streptococcus* spp. respectively (Table 7).

Table 1. Total viable count of the sampled suya in Hakimi street.

Samples	Colonies counted on plate	Dilution 10^5CFU/g	CFSS
A	130	1.30×10^7	Unsatisfactory
B	100	1.00×10^9	Unsatisfactory
C	116	1.16×10^7	Unsatisfactory
D	98	9.80×10^6	Borderline
E	92	9.20×10^6	Borderline

Note: CFU= Colony forming unit; CFSS= Centre for food safety standards ($<10^5$, satisfactory; $10^{5-}<10^6$, borderline; $\geq 10^6$, unsatisfactory).

Table 2. Total viable count of the sampled suya in Yelwawa.

Samples	Colonies counted on plate	Dilution 10^5 CFU/g	CFSS
F	148	1.48×10^7	Unsatisfactory
G	196	1.96×10^7	Unsatisfactory
H	126	1.26×10^7	Unsatisfactory
I	142	1.42×10^7	Unsatisfactory
J	116	1.16×10^7	Unsatisfactory

Note: CFU= Colony forming unit; CFSS= Centre for food safety standards ($<10^5$, satisfactory; $10^{5-}<10^6$, borderline; $\geq 10^6$, unsatisfactory).

Table 3. Total viable count of the sampled suya in Mobile Base.

Samples	Colonies counted on plate	Dilution 10^5 CFU/g	CFSS
K	128	1.28×10^7	Unsatisfactory
L	162	1.62×10^7	Unsatisfactory
M	86	8.60×10^6	Borderline
N	98	9.80×10^6	Borderline
O	152	1.52×10^7	Unsatisfactory

Note: CFU= Colony forming unit; CFSS= Centre for food safety standards ($<10^5$, satisfactory; $10^{5-}<10^6$, borderline; $\geq 10^6$, unsatisfactory).

Table 4. Total viable count of the sampled suya in Takuradua.

Samples	Colonies counted on plate	Dilution 10^5 CFU/g	CFSS
P	86	8.60×10^6	Borderline
Q	118	1.18×10^7	Unsatisfactory
R	122	1.22×10^7	Unsatisfactory
S	164	1.64×10^7	Unsatisfactory
T	170	1.70×10^7	Unsatisfactory

Note: CFU= Colony forming unit; CFSS= Centre for food safety standards ($<10^5$, satisfactory; $10^{5-}<10^6$, borderline; $\geq 10^6$, unsatisfactory).

Table 5.Variations in the mean total viable counts across the sampling points

Sampling points	Mean Values (CFU/g)
Hakimi street	107.2
Yelwawa	145.6
Mobile base	125.2
Takuradua	132.0
Significant Status	NS

Note: Standard Error (SE) = (+) 13.24; degree of freedom (df.) = 3; NS = non-significant ($p > 0.05$).

Table 6. Colonial and morphological attributes of the bacterial isolates.

Samples	Colonial Attributes		Gram Staining
	NA	MA	
A, O	Creamy white	No growth	+ve rod
C, D, E, M, Q, S, H, I	Creamy	Pinkish colour	+ve cocci in clusters
B, J, F, P, K, R	Milky	No growth	-ve rod
G, N, L, T	Milky yellow	No growth	+ve cocci in chains

Note: NA = Nutrient agar, MA = MacConkey agar, +ve = positive, -ve = negative.

Table 7. Biochemical characterization of the bacterial isolates.

Gram staining	Biochemical Tests										Identity
	Ct	Cg	Ca	In	MR	VP	Ox	Mo	Su	Gu	
+ve rod	+	-	+	-	-	+	+	+	+	+	*Bacillus* spp.
+ve cocci in clusters	+	+	+	-	+	+	-	-	+	+	*Staphylococcus* spp.
-ve rod	+	-	-	+	+	-	-	+	+	+	*Escherichia coli*
+ve cocci in chains	-	-	-	-	-	-	-	-	+	+	*Streptococcus* spp.

Note: +ve = positive, -ve = negative; Ct= Catalase; Cg= Coagulase; Ca= Citrate; In= Indole; MR= Methyl red; VP= VogesProskauer; Ox= Oxidase; Mo= Motility; Su= Sucrose; Gu= Glucose.

Table 8. Prevalence of bacterial isolates in sampled suya across the sampling points.

Isolated Bacteria	Hakimi street	Yelwawa	Mobile Base	Takuradua	Total	Percentage (%)
Staphylococcus spp.	1	1	1	3	6	30
Escherichia coli	3	2	2	1	8	40
Streptococcus spp.	0	1	1	1	4	20
Bacillus spp.	1	0	1	0	2	10
Total					20	100

In this study, the detection of these bacteria on the sampled suya could have resulted from poor processing method, poor hygiene practice, improper and unhygienic handling of the product, bad sanitation operations and unclean trays employed in hawking the product. Similar results were reported by other researchers where they could detect *Staphylococcus* spp., *Escherichia coli*, *Streptococcus* spp. and *Pseudomonas* spp. in suya samples assayed in Enugu city, Enugu State and Ilaro, Ogun State in Nigeria (13, 14). It has equally been reported that top on the list of contamination sources regarding meat products has got to do with handling during the course of preparation and eventual display of finished product for sale (24). However, during sampling of the suya assayed in this study, important factors that were noticed which could have contributed to the enormous bacterial load recorded could be unhygienic handling of the suya, exposure to a dusty environment and inability of the hawkers to pre-heat the suya before dispensing it to the final consumers. Interestingly, flies have got the capability to contaminate food products while they come in contact with food items after travelling from a dirty atmosphere (15).

The frequency of occurrence of each bacterium isolated in the sampled suya from each hawker and the overall percentage of the occurrence of each bacterium isolated and identified are presented in Table 8. The percentage of occurrence of bacteria isolated in relation to all the retail outlets was highest for *Escherichia coli* with 40% which probably may arise from the use of non- potable water during washing of raw meat (Table 8). This result is in agreement with the previous report of Umoh (2004) as regards the occurrence of bacteria in ready-to-eat food items (5).

According to Health Laboratory Service Guidelines (HLSG) for bacteriological quality of ready-to-eat foods at the point of sales, the presence of *Staphylococcus* spp. renders such food items unacceptable for human consumption (25). The presence of *Staphylococcus* spp. in the assayed suya might be due to contamination from aerial spores carried in the air. This assertion agrees with the report of (26) on the cross-contamination emanating from the handlers of meat during processing as this bacterium is a normal flora of the skin. The detection of *Staphylococcus* spp.in the sampled suya can equally be attributed to the poor hygienic practices of the vendors. The detection of *Streptococcus* spp. (20%) and *Bacillus* spp. (10%) in the assayed suya samples indicated its contamination with various bacterial species and some enteric bacteria. However, we observed that *Escherichia coli* was isolated from samples (C, D S, Q, M, G, H and I) with 40% prevalence across the sampling points (Table 8). In the same vein, *Staphylococcus* spp. was isolated from samples (P, R, J, K, E and B) in this study with 30% prevalence across the sampling points (Table 8).

Additionally, the detection of the bacteriological contaminants in the sampled suya assayed in this current study is in line with the reports of other researchers regarding the presence of similar bacteria in the suya processed and sold in their respective study areas (4, 7, 9). Similarly, the findings are in line with the reports on the possibility of having bacteriological contaminants on poorly processed suya which may in turn constitute hazards to the health of final consumers (10, 27). The detection of the bacteria in the sampled suya also agrees with previous report on the possibility of any food item emanating from animal origin (either cooked or otherwise) containing a great level of bacterial loads (28). The availability of rich nutrients that optimally support bacterial growth can be said to have played a huge role in the presence of the bacteria recorded on the sampled suya in this present study (22). The detection of these bacterial contaminants on the suya assayed in this study further supports that the poor handling of the meat by butchers being the major source of contamination coupled with the use of contaminated equipment and water in the processing stage (14). Again, the level of

personal hygiene amongst the vendors of suya equally plays a huge role in the contamination of ready-to-eat food products as humans are known to be the principal source of contaminants mostly found (29).

The viable bacterial count recorded in this study was comparatively high, which makes the consumption of the sampled suya a cause for apprehension owing to the conventional limits indicated by the guidelines for acceptable bacteriological quality of ready-to-eat food samples at the point of sale (21). On the other hand, the detection of *Staphylococcus* spp. in this study is a pointer to poor handling of the suya as this bacterium is usually found in hands, on the skin and clothing of food vendors. Most of the people that get involved in the processing and sale of suya generally do not have any formal education or training thereby lacking the prerequisite knowledge on how to handle ready-to-eat foods hygienically (30). Generally, the detection of the bacteriological contaminants on the assayed suya samples might have emanated from the way it was handled during processing and onward serving to the final consumers, the utensils and receptacle used in the processing and eventual sale, the ingredients most especially spices used for giving it the desired aroma. These factors and most especially spices have been attributed, as the chief source of contamination that ready-to-eat food products are exposed to (31).

CONCLUSION AND RECOMMENDATIONS

The findings of this investigation have allowed us to draw the conclusion that bacterial contamination was detected in all of the analyzed suya samples. Some of the bacteria isolated and found in the suya sampled in this study have the potential to be a public health concern because of their presence in such meat products is still thought to be one of the main causes of gastrointestinal problems, food poisoning, and diseases linked to food borne illness. The bacteria isolated from the suya have shown that handling and preparation standards have not significantly changed over time. In view of the bacteriological quality of the sampled suya in this study, proper hygiene must be ascertained to ensure safety from ingesting the detected bacterial contaminants upon its consumption. Considering the fact that suya constitutes a great source of protein which is needed for body building and repair of worn-out tissues in human, adequate steps must be taken to prevent contamination by microorganisms. A quality control unit that will be charged with the sole responsibility of ensuring the safety of ready-to-eat food products should be established in Nigeria. Priority should be given to the Hazard Analysis Critical Control Point (HACCP) concept in the processing and rendering of meat and related products. This will significantly lower the contamination and deterioration of meat products. Final consumers of ready-to-eat suya should also make sure to pre-heat the food before consumption to prevent consuming any potential bacteria that may be on it.

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