



Comparative Bacteriological Quality of Retail Roast Meat Products in Parts of Kaduna and Zaria Towns, Nigeria

*Bello, S.

Department of Microbiology, Baze University, Abuja, Nigeria

*Corresponding Author's Email: sakina.bello@bazeuniversity.edu.ng

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ABSTRACT

Bacillus cereus is an opportunistic pathogen of humans, and a frequent cause of food poisoning. Widely distributed in the environment, it is easily spread to many types of foods and has been referred to as the major problem in convenience foods and mass catering owing to its spore forming ability. This study compared the bacteriological quality of 3 street-vended roast meat products of northern Nigeria- *suya* (spiced roast meat), *balangu* (unspiced roast meat), and *soye* (hawked spiced roast meat) in some parts of Kaduna and Zaria towns of Nigeria, particularly as it relates to their quantitative bacteriological quality, and to the presence of *B.cereus*. A total of 129 samples comprising 43 samples each of *Suya*, *Balangu* and *Soye* were subjected to 10 fold serial dilutions and plated onto sterile plates of Nutrient agar and Mannitol Egg-yolk Polymyxin Agar (MYP) for Total Aerobic Plate Count (TAPC) and *B.cereus* isolation respectively. Presumptive *B.cereus* colonies were identified biochemically using a Microgen™ Bacillus ID. Mean TAPC was highest for *soye* ($6.3 \pm 1.0 \log_{10}$ cfu/g) and lowest for *suya* ($3.9 \pm 0.9 \log_{10}$ cfu/g). Similarly, mean *B.cereus* counts was highest for *soye* ($2.4 \pm 0.3 \log_{10}$ cfu/g), and lowest for *suya* ($1.4 \pm 0.3 \log_{10}$ cfu/g). Frequency of occurrence of *B.cereus* was highest for *balangu* at 7 (16%) and lowest for *Soye* at 3 (7%). There were no significant differences in *B. cereus* count and TAPC amongst samples of the same product at 5% level ($P > 0.05$). Study revealed TAPC and *B.cereus* counts being at levels considered satisfactory and marginal for *suya* and *balangu* respectively at the point of sale but unsatisfactory for *Soye*. The study highlights the need for regulatory agencies to educate *Soye* vendors on the implications of the use of substandard practices in the handling and sale of the product, and also guide consumers in their choices of vended roast meat products.

Keywords: Roast meat, *Suya*, *Balangu*, *B.cereus*, Total Aerobic Plate Count

1.0 INTRODUCTION

Street food as defined by the World Health Organization (WHO) refers to a wide variety of ready-to-eat (RTE) foods and beverages that are sold and sometimes prepared in public places, and either consumed where it was purchased or taken away and eaten elsewhere (Werkneh *et al.*, 2023). In Nigeria, street foods enjoy wide patronage around public places such as offices, schools, markets, cars and bus stations. The street foods enterprise provide a major source of income for a wide spectrum of individuals including sellers who are often poorly educated and untrained in food hygiene and who also work under crude unsanitary conditions (Negassa *et al.*, 2023; Werkneh *et al.*, 2023).

Roast meat products are very popular on the streets of Nigeria particularly in the northern part of the country where cattle rearing thrives amongst the Fulani and Hausa people of Northern Nigeria. Products are mainly from beef and mutton and would include red meat as well as the offals. These products go by different names depending on the method of preparation, the most popular ones being *Suya*, *Balangu* and *Soye*. *Suya* (Plate 1) is made from marinated and roasted boneless beef; skewered boneless beef is usually marinated with spices like

clove, ginger, pepper, salt, peanut cake and vegetable oil as well as food additives and flavorings and then smoked or roasted (Mubarak *et al.*, 2025; Izah, 2026). Following roasting, *suya* is stored in stacks in glass cabinets or open wire screened wooden cabinets (at ambient temperature) until sold. It is then heated and sometimes (depending on consumer preference) sliced and seasoned before it is served to consumers. *Balangu* (Plate 1) is usually produced from boneless mutton. Unlike *suya* where beef is thinly sliced and marinated with a number of spices, *balangu* slices are thicker and not marinated, but seasoned with very little or no spices before it is slowly roasted over low heat (glowing firewood (Riba *et al.*, 2020). Consumers relish the natural mutton taste of the product, but individuals can have a blend of hot spices served alongside the roast mutton at the time of purchase. Unlike *suya*, *balangu* is kept warm where it was cooked, on low heat until sold. *Soye* (Plate 2) on the other hand is a mixture of large chunks of lightly spiced beef and offals which is either roasted or boiled, but unlike *suya* and *balangu* which are sold where there are produced (*suya* spots), *soye* is placed in large basins and hawked in public places like car stations, markets and offices.

Street foods are perceived to be a major public health risk due to lack of basic infrastructure and services, difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility and temporary nature (Ghosh, 2007). Factors such as vending location, quality of raw materials, utensils and equipment, food preparation method as well as personnel hygiene ultimately impact on the safety of street vended foods (Klutse and Gilbert, 2025; Ogechi *et al.*, 2025). Several pathogenic microorganisms such as *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* and *Bacillus cereus* have been isolated from street vended foods (Whong *et al.*, 2006; Salisu *et al.*, 2020; Adeleye *et al.*, 2022; Ogechi *et al.*, 2025).

In Nigeria, it is common to see some street food handlers and consumers portraying a carefree attitude to the glaring hazard of improper handling and storage of ready-to-eat foods. These practices would inadvertently result in the microbial contamination of food products and may expose consumers to foodborne illnesses from pathogenic bacteria associated with such practices. Meat and meat products are highly susceptible to microbial growth owing to a rich nutrient composition (El hassan *et al.*, 2018; Almusawi *et al.*, 2025) and therefore would require careful handling in the course of processing, storage and distribution in order to prevent them becoming potential sources of microbial infections to consumers (Chukwu *et al.*, 2024).

Bacillus cereus, the type species of the “*Bacillus cereus* group”, (Xu and Kovacs, 2024), is a gram positive, spore-forming, rod shaped bacterium capable of facultative anaerobic metabolism (Jessberger *et al.*, 2020). The organism is widely distributed in the environment, mainly in the soil, from which it is easily spread to many types of foods especially those of vegetable origin. The organism has also been isolated from meat products, minimally processed vegetables, milks and dairy products and ready-to-eat foods (Rahnama *et al.*, 2023). *Bacillus cereus* is known to be able to produce five enterotoxins and an emetic toxin, which can be heat-stable or heat-labile depending on the strain (Albahri & Jessberger, 2026). Bacterial spores such as those of *B. cereus* are a major problem of food industries owing to their ability to survive the various steps in food processing which are designed to kill vegetative cells, and the ability to subsequently germinate and grow in food, consequently impacting negatively on the safety and shelf-life of food (Jessberger *et al.*, 2020). Thus the organism has rightly been referred to as the major problem in convenience foods and mass catering (EFSA, 2005).

This study is an attempt at evaluating and comparing the bacteriological quality of three popular street-vended roast meat products of northern Nigeria- *suya* (spiced roast meat), *balangu* (unspiced roast meat), and *soye* (hawked spiced roast meat) in some parts of Kaduna and Zaria towns of Nigeria., particularly as it relates to their quantitative bacteriological quality as an index of safety, and to the presence in these products of the potentially pathogenic and ubiquitous *B. cereus*.

2.0 MATERIALS AND METHODS

2.1 Sampling area:

The sampling area for this study included some parts of Kaduna metropolis, specifically Kaduna north (Ungwar rimi, Ungwar sarki and Ungwar dosa districts), Kaduna south (Tudun wada district) and Zaria town (Kwangila area). Kaduna and Zaria are regarded as the two urban centres of the state. The state occupies a central position in the map of the Federal Republic of Nigeria (10°20'N 7°45'E) and occupies a landmass of about 46,053Km², and is the 4th largest state in Nigeria by land area. Kaduna State has a tropical wet and dry climate, with an average annual temperature of 25.2°C and roughly 1000mm of precipitation annually (Wikipedia, 2025). Food samples were purchased from sellers/ vendors on some streets and markets in the study area where the samples are popularly consumed and easily accessible. Proximity to laboratory facilities was also an added factor in the selection of sampling areas.

2.2 Determination of Total Aerobic Plate Count (TAPC) of Street Vended Roast Meat Products (*Suya*, *Balangu* and *Soye*)

A total of 129 samples comprising of 43 samples of each product (*Suya*, *Balangu* and *Soye*) (figures 1 and 2) were purchased from 10 different sellers of *suya*, 8 of *balangu*, and 6 of *soye*. Samples at the time of purchase were collected in sterile containers and transported in ice pack containers to the laboratory at the Department of Microbiology, Ahmadu Bello University, Zaria. All samples were analyzed within 24h following purchase. One millilitre of appropriate 10 fold dilutions of homogenates of each sample was plated onto sterile nutrient agar (Oxoid, UK) plates for TAPC (Orpin *et al.*, 2018).

2.3 Determination of *B. cereus* counts of Street Vended Roast Meat Products (*Suya*, *Balangu* and *Soye*)

One milliliter (1ml) of appropriate 10 fold dilutions of homogenates of each sample was plated onto sterile plates of Mannitol Egg-yolk Polymyxin Agar (MYP) (Oxoid, U.K.), a selective *Bacillus cereus* medium (Zhou *et al.*, 2024). All Nutrient agar and MYP plates were then incubated at 37°C for 24-48 h until the

appearance of distinct colonies and then counted and recorded. Flat, white granular colonies that appeared.



Plate 1: Soye during sale near a bus station.



Plate 2: Roasting process in suya (skewered) and balangu (unskewered) production

surrounded by zones of clearance on pink or red backgrounds on the MYP plates were counted and recorded as presumptive *B.cereus*. *Bacillus cereus* colonies were streaked on nutrient agar slants, incubated at 37°C for 24 to 48 h, and stored at 4°C until required for characterization. Presumptive *B.cereus* isolates were identified using a Microgen™ Bacillus ID.

3.0 RESULTS AND DISCUSSION

Table 1 shows results obtained from the analysis of TAPC of retail suya, balangu and soye. Mean TAPC for 43 samples of each product showed soye having the highest mean value of $6.3 \pm 1.0 \log_{10}$ cfu/g. Lowest mean value of $3.9 \pm 0.9 \log_{10}$ cfu/g was recorded for suya. Mean total plate counts for producers of each product was lowest for producers of suya with values ranging from $3.0 \pm 0.6 \log_{10}$ cfu/g to $4.8 \pm 1.0 \log_{10}$ cfu/g and highest for producers of soye with a mean values range of $6.2 \pm 0.6 \log_{10}$ cfu/g to $6.6 \pm 0.7 \log_{10}$ cfu/g.

Similarly, mean *B.cereus* counts (table 2) for all 43 samples of each product was highest for soye at $2.4 \pm 0.3 \log_{10}$ cfu/g, and lowest for suya with mean counts of $1.4 \pm 0.3 \log_{10}$ cfu/g; Mean *B.cereus* counts (table 2) for producers of each product was highest for producers of soye with a range of $<1.4 \pm 0.0 \log_{10}$ cfu/g to $1.3 \pm 0.7 \log_{10}$ cfu/g and lowest for producers of suya with values ranging from $<1.4 \pm 0.0 \log_{10}$ cfu/g to $0.7 \pm 0.9 \log_{10}$ cfu/g.

Frequency of occurrence of *B.cereus* in samples was highest for balangu samples at 7 (16%) and lowest for Soye at 3 (7%) (Table 2). Consequently, balangu made up to 47% of positive samples, while soye constituted 20% of positive samples (figure 3). Statistical analysis using the one-way ANOVA showed no significant differences in *B. cereus* count and TAPC for all samples of the same product at 5% level ($P > 0.05$) (irrespective of producer).

Table 1: Mean TAPC of retail Suya, Balangu and Soye

Food item(n=43)	Mean TAPC ($\log_{10}$ cfu/g)	Range of mean TAPC ($\log_{10}$ cfu/g)*
Suya	3.9 ± 0.9	3.0 ± 0.6 to 4.8 ± 1.0
Balangu	5.0 ± 1.5	3.5 ± 1.5 to 5.3 ± 1.8
Soye	6.3 ± 1.0	6.2 ± 0.6 to 6.6 ± 0.7

cfu/g ; colony forming units per gram of sample

* ; Range includes mean counts for all of 10 producers of suya, 8 of balangu and 6 of soye

Table 2: Frequency of Occurrence and Mean Counts of *B. cereus* in Suya, Balangu and Soye

Food item(n=43)	No and percent (%) positive for <i>B.cereus</i>	Mean <i>B. cereus</i> count ($\log_{10}$ cfu/g)	Range of mean <i>B.cereus</i> count ($\log_{10}$ cfu/g)*
Suya	5 (12)	1.4 ± 0.3	$<1.4 \pm 0.0$ to 0.7 ± 0.9
Balangu	7 (16)	1.5 ± 0.3	$<1.4 \pm 0.0$ to 1.1 ± 0.1
Soye	3 (7)	2.4 ± 0.3	0.4 ± 0.7 to 1.3 ± 0.7

cfu/g ; colony forming units per gram of sample

* ; Range includes mean counts for all of 10 producers of suya, 8 of balangu and 6 of soye

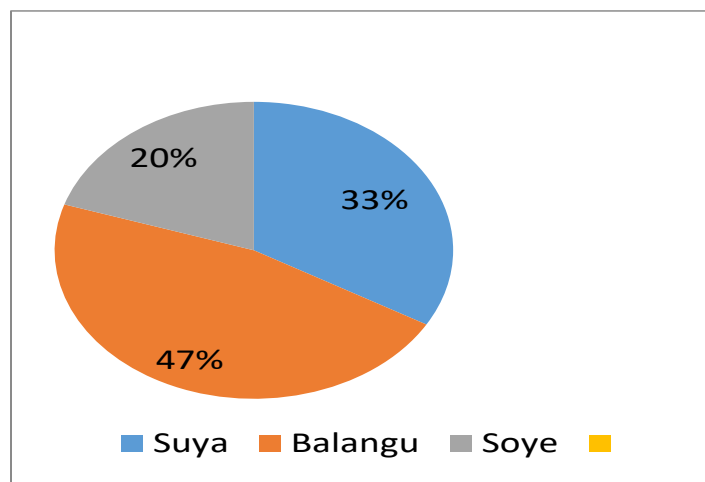


Figure 3. Percentage Distribution of *B.cereus* Across Suya, Balangu and Soye

Mean total aerobic plate counts (TAPC) for samples in this study were within satisfactory levels ($<10^4$) for *suya* and marginal ($<10^6$) for *balangu*, whereas mean TAPC for *soye* samples fell within unsatisfactory levels for ready-to-eat foods ($\geq 10^6$) which is indicative of poor food handling practices (FSAI, 2020). Mean TAPC for Suya in this study are in contrast to those reported by Mubarak et al. (2025) where samples from Gwagalada exceeded acceptable limits for ready-to-eat foods and Oyewole et al., (2024) for Suya samples from Ibadan metropolis. Whereas *suya* and *balangu* products are sold at “suya spots” where they are produced, hence are not exposed to crowded areas, *soye* products are placed in large open basins and hawked in crowded places, exposing it to contamination from bacteria associated with outdoor spaces. In addition, the practice wherein the vendor uses bare unwashed hands to pick and slice products onto old newspapers at the time of sale provide more channels for contamination with a multitude of bacteria. Differences in TAPC quality between *suya*, *balangu*, and *soye* could be attributed to the above differences in post-processing handling and sale of the products. Anihouvi et al. (2013) also reported an association between higher microbial loads and nature of retail environment; in their study, a higher microbial load was recorded for retail roast meat from highly polluted areas. Similar observations have been reported by Orpin et al., (2018). In addition, *suya* and *balangu* undergo some form of heating at the time of sale unlike *soye*. This process of heating would reduce the levels of bacterial contaminants resulting in safer products. In this study, the effect of the level of heating on microbial quality is further highlighted in the lower levels of microbial load observed for *suya* which is subjected to heating by placing around flames at the time of sale, whereas *balangu* (which is usually kept warm over glowing

coals) is at the time of sale packaged without any additional heat treatment.

Mean *Bacillus cereus* counts for samples in this study were at levels considered as satisfactory ($<10^2$) for *suya* and *balangu* and presented no food safety concern (FSAI, 2020), but at marginal levels for *soye* (10^2 to $<10^3$). Marginal levels in counts though within expected microbiological levels that present no food safety concern, are suggestive of process controls not fully achieved or contamination of raw materials (FSAI, 2016). The highest frequency of occurrence of *B.cereus* recorded for *balangu* in this study could be attributed to the heat resistance of *B.cereus* spores, and their ability to survive the various steps in food processing which are designed to kill vegetative cells (Jessberger et al., 2020). Yusuf et al., (2012) also reported *B.cereus* as having the highest frequency of occurrence in *balangu* from Bauchi metropolis, Nigeria. *Balangu* is kept warm over glowing coals until sale, which may destroy other vegetative cells and not *B.cereus* spores. It could therefore be deduced that *balangu* consumption predisposes consumers more to *B.cereus* associated foodborne illnesses than *suya* and *soye*. A number of researchers have reported the presence of *Bacillus* species in roast meat products in Nigeria (Osuji et al., 2024; Oyewole et al., 2024).

Interestingly, it was noted that frequency of occurrence of *B.cereus* in the meat products in this study was lowest for *soye* in spite of the product being hawked and exposed to open crowded environments associated with high levels of microbial contamination as is evident with *soye* samples having highest TAPC counts of the 3 products analysed in this study. This low frequency of occurrence of *B.cereus* could be as a result of presence of microbial associations that could inhibit growth of the *B.cereus* bacteria. A number of studies that analyzed the



bacterial profile of retail traditional meat products have reported the presence of similar associations of bacterial species across these products. Similar bacterial species including *Staphylococcus*, *Streptococcus*, *Bacillus* spp, *E.coli*, *Salmonella*, *Klebsiella*, *Shigella*, *Citrobacter*, *Campylobacter* spp, *Clostridium perfringens*, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Vibrio parahaemolyticus* have been isolated from traditional roast beef processed sold under conditions that enable contamination from these bacteria (Yang *et al.*, 2014; Orpin *et al.*, 2018, Ike and Ogwuegbu, 2020; Adeleye *et al.*, 2022). A number of these organisms are known bacteriocins producers. Bacteriocins are antimicrobial peptides produced by bacteria, which can kill or inhibit bacterial strains closely-related or non-related to producer bacteria, but will not harm the bacteria themselves due to some inherent characteristics (Singh *et al.*, 2013; Yang *et al.*, 2014, Dabire *et al.*, 2021). Some bacteriocins from *B. thuringiensis* which is ubiquitous in the environment and closely related to *B.cereus* have been found to inhibit *B. cereus* (Lee *et al.*, 2009; Deng *et al.*, 2022).

4.0 CONCLUSION

This study has revealed that *suya* and *balangu* sold within some areas of Kaduna metropolis have TAPC and *B.cereus* counts at levels considered satisfactory and marginal and do not present food safety concerns at the time of sale. There is however the potential of these levels exceeding these limits to reach unsafe levels with poor food storage conditions following sale. Total aerobic plate counts for *Soye* hawked in some parts of Zaria town are however at unsatisfactory levels indicative of poor food handling practices, whereas *B.cereus* counts are at marginal levels. Findings also suggest an antagonistic relationship between *B.cereus* and other bacteria associated with poor unhygienic food handling practices. This study has highlighted the impact of processing technique and post processing handling and sale practices on the overall bacteriological quality and presence of *B.cereus* in *suya*, *balangu* and *soye*.

5.0 RECOMMENDATIONS

Regulatory agencies would need to enlighten producers of these products, particularly *soye*, and ensure that standard techniques are employed in the processing and handling of hawked products such as *soye* in order to improve on the bacteriological quality ensure safety of consumers.

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