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Quality Evaluation of *Suya* Meat Sold in Open Markets in Ondo Metropolis, Nigeria

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Abstract

This study was carried out to evaluate the chemical and microbial qualities of suya meat sold in Ondo city metropolis, Ondo state Nigeria. A total of thirty (30) samples from three different locations, Sabo area – (Site I), Yaba area - (Site II), Adeyemi College area - (Site III) were randomly collected. Control samples of suya were prepared in the Laboratory to provide adequate hygienic condition of the suya sample. All suya samples were subjected to chemical analysis and microbiological examination – aerobic plate counts (APC), Staphylococcal counts (SC), Fungal counts (FC) and Coliform counts (CC). Suya from Site II had significantly ($p < 0.05$) higher in moisture values (8.42%) than suya from the control (6.76%), Site I (6.09%) and Site III (6.54%). Fat and ash contents were significantly ($p < 0.05$) higher in Control (23.43%) and (8.77%) respectively than Suya from other sites. Microbial counts were high in commercial suya samples with mean APC of 4.3 x 10^5, Coliform Counts of 3.3 x $10,^5$ FC of 5.7 x 10^4 in Site I while Staphylococcal counts was 7.2 x 10^4 in Site III. The general evaluation of microbial species showed the presence of Staphylococcus aureus, Bacillus subtilis, Escherichia coli and Klebsiella spp in commercial suya which could pose high health risk to consumers. It is therefore advised that processors/vendors of suya should imbibe good hygienic practices in order to improve the quality and reduce the risk of food borne diseases while consuming this product.

Keywords: Quality, *Suya* meat, Open market, Evaluation

Introduction: *Suya* is a popular West African delicacy particularly in Nigeria that consists of skewered and grilled meat, often served with a flavorful peanut sauce. It is a beloved street food known for its rich spicy and smoky flavors. *Suya* can be made from various meats such as beef, chicken or goat and is seasoned with a blend of spices including chili peppers, ginger, garlic and ground (peanuts). Meat are rich sources of essential and beneficial mineral needed for body morphological process, eaten and a good source of protein and fats, plays major role in the intake of a number of nutritional and trace elements in human health (Okodugha,and Banu, 2015). *Suya*, a popular ready - to - eat meat in Nigeria comes in various forms, including skewered meat. The spices used are locally sourced and the dried ingredients are prepared for street sale (Zahraddeen *et al*, 2017). Suya is made from boneless meat threaded onto sticks, and seasoned with a blend of peanut cake, salt, vegetable oil and other flavorings, before being roasted over a charcoal fire.

In the tropics, meat spoils rapidly few hours after the onset of rigor mortis, hence the need for meat to be preserved in order to maintain its quality. One of the ways of preserving meat is processing. Processing enhances meat quality as well as elongates shelf-life. Processed meat products are defined as those in which the properties of fresh meat must have been modified by the use of one or more procedures such as gridding, addition of seasoning agents, alteration of colour or heat treatment. Various processing methods are employed in the preservation of meat and these include drying, salting, curing, incorporation of additives, refrigeration and freezing. Meat from cattle, sheep, goats and chickens can be processed into products like *suya, kilishi, Tsire, Asun, Balangu* which are commonly served or sold along streets, in club- houses, at picnics, restaurant and within institutions. The microorganisms which are found to contaminate and cause spoilage of meat and meat products are bacteria, yeast and moulds. These organisms are introduced into meat by butchers and workmen or through water and air in the dressing, cooling and cutting rooms or tables and even from the environment. The high ambient temperature, humidity, shortage of portable water and poor handling practices predisposes meat and meat products to massive microbial contamination which consequently lead to rapid deterioration and even poisoning (Abdullahi, *et al.*, 2015). The increasing demand for *suya* meat in Urban Nigerian markets particularly in metropolis has raised concern about the quality and safety of the products. With limited regulatory oversight and varying preparation methods, there is a lack of standardized criteria for assessing the quality of *suya* meat. This situation poses significant risks to public health and consumers' confidence. Therefore there is critical need to establish comprehensive evaluation protocols to ensure that consistent quality and safety of *suya* meat sold in open market within the metropolis. The escalating popularity of *suya* meat in urban Nigerian markets notably within bustling metropolises has given rise to apprehensions regarding the reliability and safety of the products. This research therefore was carried out to determine the qualities of *suya* as obtainable by consumers from open market through microbial and fungal load evaluation.

Materials and Methods:Experimental location: The study was conducted in the Department of Animal Science laboratory, Adeyemi Federal University of Education, Ondo,

Nigeria. Ondo state is situated in the south west rain vegetation belt of Nigeria. It lies within latitudes 7^0 10'N of Equator and longitude 3^0 2'East of Greenish Meridian and Altitude 76mm. It is located in the derived savannah zone of South-Western Nigeria. The area is dominated by plains 200m above sea level. It has a humid climate and annual rainfall of about 1700 to 2500mm which is concentrated almost entirely between March and October. Average relative humility is about 80% with up to 90% occurring during rainy season. The mean daily maximum air temperature ranges from 28 to 35°C while mean daily minimum ranges from 19 to 24°C (Acuweather, 2016).

Experimental materials: Samples were collected from three locations in Ondo Metropolis, Ondo state which include: Yaba (site I), Sabo (Site II), Adeyemi site (Site III). Each of the sampling sites was randomly chosen among all the *Suya* vendors in the study area.

Collection of materials: A total of thirty *Suya* samples were randomly obtained from the vendors in the production sites for two days. Samples were aseptically introduced into pre-sterilized plastic packs and transported to the meat science laboratory of the department of Animal science, Federal University of Technology Akure for immediate analysis.

Preparation of *Suya* meat in the Laboratory (Control Experiment): Three (3) kg meat of semi-membranous muscle tissue was obtained from the hindquarter of freshly slaughtered cow at a local abattoir in Ondo Metropolis. The tissue was then trimmed to remove excess fat, nerves, blood vessels and connective tissues. The meat was cleaned, refrigerated for 2 hours and then cut into thin slices (1–1.5mm thick) along the fibre axis. The sliced beef was properly washed and portioned into small chunks (50-100g). *Suya* spices (5 spoons) and salt (0.5 teaspoons) were mixed and set aside (see Table 1). The beef slices were threaded onto sticks, brushed with vegetable oil and evenly coated with the spiced mixture. Grilling was done using an electric grill, with the *suya* turned every 10 minutes. Additional spices and oil were applied after 20 minutes and grilling continued for another 20 minutes and the products were ready for consumption.

Microbial analysis: Plate count agar (PCA) Nutrient agar (NA), Mannitol salt agar, Salmonella shigella agar (SSAY), Eosin Methylene Blue Agar (EMB) and Malt Extract Agar (MEA) were used to carry out bacteriological and mycological analysis of *suya* samples at the Microbiology laboratory of Department of Animal Science, Federal University of Technology Akure. These were prepared according to manufacturer's instructions and aseptically distributed into sterile petri dishes. 25 grams of each of the meat samples were weighed and transferred into 225ml of peptone water in a bucket. Serial dilution was prepared from 10^2 to 10^6 and plated. They were incubated at 37°C for 1-2days except for yeast and moulds that were incubated for 10 days.

Morphological studies: Colonies, which developed after incubation, were examined for cultural features such as elevation, size, and surface form, degree of growth, opacity and pigmentation. Pure cultures of the associated microorganism were obtained by repeated streaking on nutrient agar plates for bacterial and fungal isolates. Cellular characteristics of pure culture of each isolated microorganism (bacterial) were examined under the microscope using the oil immersion x 100 objective after gram staining.

Biological Characteristics of Isolates: Biological Isolates: various tests were carried out on the bacterial isolates for possible
identification. In each case, a fresh culture was used for every biochemical test.

Mycological Examination of Samples: Fungal and yeasts insolates were examined physically on plates based on colour and hyphae formation. The characteristics of isolates were identified using methods described
by Devise, (2012).

Chemical Analysis: The chemical composition of samples of *suya* from both control (production in the laboratory) and sites (different location) were carried out following the procedures to
SAS (2001)

Statistical Analysis: Data were subjected to analysis of variance (ANOVA) according to (AOAC 2010). The Duncan Multiple Range Test subjected treatment means to comparison

Results and Conclusions: Chemical composition of commercial and control *Suya*: The mean chemical analysis of *Suya* is shown in Table 2. The result shows that there were significant differences ($p<0.05$) between moisture, fat, ash and fibre in the *suya* products obtained from various locations of the study area. However, no difference was observed for protein and carbohydrates ($p<0.05$). No significant variation occurred in the moisture content of *suya* in control (6.76%), site I (6.09%) and site III (6.54%). The fat and ash composition had the same trend. The fat content of *Suya* produced in the laboratory (control) was significantly ($p<0.05$) higher (23.43%) compared to the commercial samples from site I (21.37%), site II (18.04%) and site III (22.78%). Similarly the ash content of control was significantly ($p<0.05$) higher (8.77%) compared to the commercial samples from sample I (8.14%), Site II (6.45%) and site III (8.53%). However, *suya* from site II had the least fat (18.04%) and ash (6.45%) contents. The crude fibre of *suya* from control and site II were not significantly different from each other with mean value of 0.62% while the lowest significant value was observed from Site I (0.40%). No significant difference was observed in crude protein content of *suya* with mean values ranging from 50.18% to 52. 70% and carbohydrates with mean values ranging from 18.08% to 18.24% respectively.

The result obtained for this study was lower than those recorded in previous works by Mgbemere *et al.*, (2011) who recorded mean moisture percentage of 11.6%; Abdullahi, *et al.*, (2015) obtained mean moisture percentage of 12.4%, Muhammed (2017) recorded 13.73% while Olusola, *et al.*, (2017) recorded a value of 8.99 % for traditional *suya*. The difference could be due to processing method which led to reduced water activity of the products. Water activity is the term for the amount of free (not chemically or physically bound) water which is available for the growth of microorganism (Olusola *et al*., 2017). The moisture content obtained in the study indicated that the products were well dried and thus prevented microbial spoilage. The range of values obtained for protein content was however in agreement with previous works on *suya*. Igene *et al.*, (2016) reported a value of 50.02% for traditional *suya* after roasting, Mgbemere *et al*., (2011) obtained 49.8% for *suya* while Olusola *et al*., (2017) recorded 62.33% for *suya*. The major part of the protein in *suya* is usually gotten from the groundnut paste used (Badau *et al*., 2017). All other ingredients do contribute their quota of protein too; making *suya* a food or snacks reach in protein

(Adaku *et al*., 2016). The ash content of fresh meat is about 1% on wet basis, processing however increases this level significantly. On the dry weight basis, it contains 3.5% mineral components (Jones *et al.*, 2011). The high ash content values recorded in this study could be due to individual mineral level of spices used in slurry formulation for processing combined with the ash content of the meat samples used for production. Ash content of 7.83% for traditional prepared *suya* prior to roasting was also reported by Igene *et al.*, (2016).

Meats do not contain dietary fibre, however crude fibre was determined since elements that constitute the spices used in *suya* production are of plant origin. Abdullahi, *et al.*, (2015) reported crude fibre of 3.1% for *suya* and Apata *et al*., (2012) obtained values of 0.13 to 0.17 for *suya* with different drying methods. The significant differences obtained could be due to the ingredient composition and varied rate of absorption and adsorption of the dried raw meat slices in the slurry. The substantial part of carbohydrate content of the products in this study could have been contributed by the ingredients in the slurry since they are of plant origin which is high in common sugars.

Microbial counts of commercial and control *suya*.: The microbial counts of *suya* products from various sites and control are presented in Table 3. Significant difference ($p < 0.05$) were observed for aerobic plate counts (APC) and fungal counts (FC) with site I having highest values of $4.3x10^5$ and $5.7x10^4$ respectively. *Suya* from site III also had significantly higher values of $7.2x10^4$ for SC. However, no significant difference ($p > 0.05$) was recorded for CC. Mean CC of $2.2x10^4$ which was the highest obtained in this study for *suya* samples were recorded for site I with site III having the lowest value ($1.0 x10^4$). Site I recorded the highest mean FC value of $5.7 x10^4$ while control had the least value of $2.5 x10^4$. Micro-organisms counts obtained during the bacteriological survey of the products from the control and the various production sites showed relatively high APC in the samples. These counts were however within the upper limit set by Vasavada, (2018) in which mean APC of sliced meat products should not exceed 10^6cfu/g. According to Apata *et al*.(2012), influence of environmental sanitation on the microbial population is a highly significant factor in the quality of *Suya* and *kilish*i. Abdullahi, *et al.*, (2015) recorded APC of less than 10^6cfu/g for *suya* from various sites in Zaria and Badau *et al*., (2017) recorded an APC acceptable limit of 10^5-10^8 suggested by Adaku *et al*., (2016) for processed ready-to-eat chicken.

There is however an exception for the control *suya* and *suya* from site II that did not record any counts for Coliforms. *Suya* from sites I and III recorded very high CC of 10^4cfu/g against the maximum standard of 10^2cfu/g.

Biochemical characterization of the bacterial isolates from *suya* samples: In Table 4, it was observed that Coagulase positive S. aureus was present in the products from all sites except in the control. This high SC is a point of public health concern since the growth of Staphylococcus aureus to a population of 10^5cfu/g is considered necessary for the production of 1ug of enterotoxin sufficient to cause intoxication if such food is consumed. The presence of high levels of this coagulase positive Staphylococci indicated man and environmental contamination (Vasavada, 2018) and this is in agreement with earlier reports of Apata, *et al*, (2012). Also the isolation of *Coliforms* in some of the products could be an indication of contamination and recontamination, a theory described by (Badau *et al*., 2017). *E.coli, Klebsiella spp* and other Coliforms are organisms of intestinal origin which get into foods through indiscriminate touching by handlers and buyers with poor sanitary habits Abdullahi, *et al*, (2015). The fungal species isolated from *suya* products also pose high health risk to consumers. Growth of moulds on meat can cause spoilage of the affected parts and can also release toxins into food (Robert *et al* 2016). If consumed in food they can in a long term have carcinogenic effects. A number of researchers (Igene, *et al* , 2008; Abdullahi, *et al.*, (2015) have also reported same trends of findings whereby *suya* products sold in Nigeria are contaminated with various species of bacteria and fungi. Badau *et al*., (2017) stated that the source of contamination on these products could also come from the utensils, from the air and from the spice ingredients because according to Vasavada, (2018), spices may serve as a source of contamination to processed meat products.

Conclusion: The results of this study showed acceptable level of nutritional composition of *suya* products from different production sites and the control. However, the microbial loads observed were higher in the commercial samples than the control products and this level of contamination is at a point of being potentially hazardous to consumers.

Recommendations: It is recommended that the public must be aware of the consequences of selling and purchasing *suya* in parks, along the streets and other open places and this should be discouraged. However, adequate covering of the *suya* at the selling points may minimize its contamination from dusts, gaseous fumes from vehicle exhausts. There is need to avoid direct heating of *suya* with charcoal fire rather the use of electric microwaves. This should be encouraged to optimize high level of hygiene. Good hygienic practices during packaging and storage are highly recommended to safeguard the health of consumers.

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Table 1: Ingredients Composition for Suya Slurry

Ingredients	Quantity (%)
Groundnut paste	38
Cloves	2.5
Black pepper	2.5
Red pepper	3.4
Sweet pepper	1.10
Alligator pepper	1.10
Onion powder	1.80
Garlic powder	6.70
African nutmeg	0.50
Curry	1.00
Salt	0.70
Seasoning powder	0.10
Paprika powder	2.10
Vegetable oil	36
Ginger powder	2.5
Total	**100**

Table 2: Chemical Composition (%) of Suya samples

Treatment	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
Control	6.76^{b}	51.45	23.43^{a}	8.77^{a}	0.62^{a}	18.24
Site I	6.09^{b}	50.18	21.37^{b}	8.14^{b}	0.40^{c}	19.02
Site II	8.42^{a}	52.57	18.04^{c}	6.45^{c}	0.62^{a}	18.08
Site III	6.54^{b}	52.70	22.78^{ab}	8.53^{ab}	0.45^{b}	18.16
SEM	0.22	0.32	0.29	0.13	0.03	1.06

^{abc} means bearing different superscripts within the same column differ significantly ($p<0.05$) Site I= Sabo area, Site II = Yaba area, Site III Adeyemi Area

Table 3: Microbiological Analysis of *Suya* samples (cfu/g)

Treatments	APC	SC	CC	FC
Control	$2.2x10^{5b}$	$2.1x10^{4b}$	$1.2x10^{4}$	$2.5x10^{4c}$
Site I	$4.3x10^{5a}$	$3.3x10^{4b}$	$2.2x10^{4}$	$5.7x10^{4a}$
Site II	$2.5x10^{5ab}$	$2.6x10^{4b}$	$1.2x10^{4}$	$3.4x10^{4b}$
Site III	$3.1x10^{5ab}$	$7.2x10^{4a}$	$1.0x10^{4}$	$4.8x10^{4a}$
SEM	$6.2x10^{4}$	$1.5x10^{4}$	$1.3x10^{4}$	$2.2x10^{4}$

[abc] Means bearing different superscripts within the same row differs significantly ($p<0.05$). APC= Aerobic plate counts, SC= Staphylococcal counts, CC= Coliforms counts, FC= Fungal counts, Site I= Sabo Area, Site II= Yaba Area, Site III Adeyemi area, .SEM= Standard error of the mean, cfu/g = colony forming unit per gram.

Table 4: Biochemical characterization of the bacterial isolates from suya samples

Treatment	Gmrxn/CM	Catalase	Coagulase	Indole	Citrate	Motility	TSI	MR	VP	Organism
Control	-	-	-	--	-	-	-	-	-	None
S-I_1	+ve cocci in clusters	-	+	-	-	-	-	-	-	S.aureus
S-I_2	-ve (short) rods	-	-	+	-	-	-	+	-	E.coli
S-II_1	+ve cocci in clusters	-	+	-	-	-	-	-	-	S.aureus
S-II_2	+ve cocci in clusters	-	+	-	-	-	-	-	-	S.aureus
S-III_1	-ve (short) rods	-	-	+	-	-	-	+	-	S.aureus
S-III_2	+ve cocci in clusters	-	+	-	-	-	-	-	-	S.aureus

Gmrxn/CM= Gram reaction per cell morphology, MR= Methyl Red, VP= Vogesproskauer, TSI= Tripple Sugar Iron, +ve= positive reaction, -ve= negative reaction, S.aureus= Staphylococcus aureus, E. coli= Eucherichia coli, S-$I_{1\&2}$ = Site 1 and 2