Evaluation of Quality Characteristics of Suya Produced in Wukari Metropolis of Taraba State, Nigeria

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Abstract

Suya a flavorful grilled meat product which originated from West Africa particularly Nigeria is made from skewered thin sheets of meat which are coated with blend of spices (Yaji) grilled over an open flame. Suya can be made from beef and other meats. It is a source of essential nutrient such as protein, fats, vitamins, and minerals. It is the most common ready-to-eat meat product among Nigerians and has permeated the society, because of its affordability and availability. The processing, preservation, and packaging of suya have significant implications for food safety, shelf life extension, and product quality. Hence, in the evaluation of quality characteristics of suya produced in Wukari metropolis, Taraba State. Randomized sampling method was used to sample suya produced at four different locations namely: (Hospital, Puje, Avyi and Chonku Wards, within Wukari Metropolis. Nine replicate samples were randomly collected from each of the four locations, each of the locations with three replicates and three samples per replicate in a completely randomized design. A total of 36 samples were collected and analyzed for proximate and microbial counts. The mean scores obtained from the proximate analysis and microbial counts were subjected to Analysis of Variance (ANOVA). No significant differences ($p>0.05$) were observed in the proximate composition while significant differences ($p<0.05$) were found in the microbial counts except in fungi. Proteus spp, Staphylococcus aureaus, Bacillus cereus, Enterobacter aerogenes, yeasts and moulds were isolated from the suya samples. The highest microbial counts were found in suya from Hospital Ward in Proteus spp, Staphylococcus aureaus, Enterobacter aerogenes and Fungi (4.2788, 5.2989, 4.477, 4.7284 log_{10} CFU/g) respectively except in Bacillus cereus where suya samples from Chonku Ward had the highest count (5.1903 log_{10} CFU/g) than other suya samples while the lowest counts (4.5441 log_{10} CFU/g a) of Fungi and absence of Proteus spp, Bacillus cereus, Enterobacter aerogenes were found in Puje ward. Therefore suya samples collected from the four wards were safe for consumption since they fall within the recommended range of 10^6 CFU/g as satisfactory limit, and 10^6 to $<10^7$ CFU/g as acceptable range but the samples from Puje Ward were safer and wholesome for consumption since it had lower microbial counts compare to other samples. Therefore suya processors and vendors in Wukari Metropolis should improve their hygiene and sanitation practices to avoid contamination of the products.

Key words: Suya; Wukari; proximate composition; microbial count; marinate; grilled

Running title: Quality of suya in Wukari Metropolis

Évaluation des caractéristiques de qualité du Suya produit dans la métropole de Wukari, État de Taraba

Résumé

Suya est un produit de viande grillée savoureux originaire de l'Afrique de l'Ouest, en particulier du Nigéria, composé de fines tranches de viande enfilées sur des brochettes, recouvertes d'un mélange d'épices (Yaji) et grillées sur une flamme ouverte. Le Suya peut être fait à partir de viande de bœuf et d'autres viandes. Il constitue une source de nutriments essentiels tels que des protéines, des graisses, des vitamines et des minéraux. C'est le produit de viande prêt à manger le plus courant parmi les Nigérians et a pénétré la société en raison de son accessibilité et de sa disponibilité. Le traitement, la conservation et l'emballage du Suya ont des implications importantes pour la sécurité alimentaire,

l'extension de la durée de conservation et la qualité du produit. Ainsi, dans l'évaluation des caractéristiques de qualité du Suya produit dans la métropole de Wukari, État de Taraba, la méthode d'échantillonnage aléatoire a été utilisée pour prélever du Suya produit à quatre endroits différents : (Hôpital, Puje, Avyi et Chonku Wards, dans la métropole de Wukari). Neuf échantillons répétés ont été prélevés au hasard dans chacun des quatre endroits, chaque endroit ayant trois réplicats et trois échantillons par réplicat dans un design complètement aléatoire. Un total de 36 échantillons a été collectés et analysés pour leur composition proximate et leurs comptages microbiens. Les scores moyens obtenus à partir de l'analyse proximate et des comptages microbiens ont été soumis à une analyse de variance (ANOVA). Aucune différence significative ($p>0,05$) n'a été observée dans la composition proximate, tandis que des différences significatives ($p<0,05$) ont été trouvées dans les comptages microbiens, sauf pour les champignons. Proteus spp, Staphylococcus aureus, Bacillus cereus, Enterobacter aerogenes, levures et moisissures ont été isolés des échantillons de Suya. Les comptages microbiens les plus élevés ont été trouvés dans le Suya de l'Hôpital, notamment pour Proteus spp, Staphylococcus aureus, Enterobacter aerogenes et les champignons (4,2788, 5,2989, 4,477, 4,7284 log_{10} UFC/g), à l'exception de Bacillus cereus, où les échantillons de Suya de Chonku Ward avaient le comptage le plus élevé (5,1903 log_{10} UFC/g) par rapport aux autres échantillons de Suya, tandis que les plus faibles comptages (4,5441 log_{10} UFC/g) de champignons et l'absence de Proteus spp, Bacillus cereus, Enterobacter aerogenes ont été trouvés dans le Puje Ward. Par conséquent, les échantillons de Suya prélevés dans les quatre quartiers étaient sûrs à la consommation car ils se situaient dans la plage recommandée de 10^6 UFC/g comme limite satisfaisante, et de 10^6 à $<10^7$ UFC/g comme plage acceptable, mais les échantillons du Puje Ward étaient plus sûrs et plus sains pour la consommation car ils avaient des comptages microbiens plus faibles par rapport aux autres échantillons. Par conséquent, les producteurs et vendeurs de Suya dans la métropole de Wukari devraient améliorer leurs pratiques d'hygiène et de salubrité pour éviter la contamination des produits.

Mots-clés : Suya, Wukari, composition proximate, comptage microbien, marinade, grillé
Titre courant : Qualité du Suya dans la métropole de Wukari

Introduction

Meat is an edible flesh of animals that is consumed as food by humans. It is a rich source of high-quality proteins, vitamins, minerals and healthy fats (including omega-3 fatty acids) (Ijarotimi and Keshinro, 2020). Meat can be obtained from cattle, pigs, sheep, and poultry, as well as wild game. Meat is often cooked or processed before consumption, and it is an integral part of various culinary traditions and dishes worldwide (USDA, 2020). The increasing population, urbanization, and changing dietary preferences have led to a rising demand for meat and meat products (Ewuola and Aromolaran, 2022). However in meeting these increasing demands the meat industry has faced numerous challenges which include limited infrastructure such as poor power supply, low productivity, and inefficient value chains. Therefore the need for improved production techniques was reported by (Olukosi and Erhabor, 2019). Among of the numerous methods that that have been employed to improve production is drying and smoking. Drying method has been used for ages to preserve meat. It prevents microbial growth and meat spoilage by reducing the moisture content of the meat (Beriain *et al*., 2011). Smoking meat can helps preserve the nutritional content of meat products, by reducing the degradation caused by microbial activity and enzymatic reactions (Karim *et al*., 2016). It also imparts unique flavors to meat products, enhancing their taste and flavour (Resurreccion, 2021). Additionally, drying aids in storing and transporting food by reducing the size and weight of the products and contamination of the product (Ryoba *et al*., 2013). Several native meat products have been produced with drying methods. Such as: Balangu, kilishi, dambu-nama, biltong, suya (Iyiola *et al*. 2023; Sebranek andBacus, 2017:

Thomas *et al*., 2014; Biscola *et al*., 2013;). Suya is a flavorful grilled meat product that originated from West Africa, particularly Nigeria (Obanu *et al*., 2020). It is made from skewered pieces of meat which are marinated with a blend of spices called Yaji and then grilled over an open flame (Saba *et al*., 2018). According to Adeyeye *et al*. (2019) suya can be made from beef and other meats such as chicken, chevon and mutton. Suya is a source of essential nutrient such as protein, fats, vitamins, and minerals (Okonkwo *et al*., 2012). The processing, preservation, and packaging of meat products, particularly suya have significant implications for food safety, shelf life extension, and product quality (Saba *et al*., 2018). According to Ahmed *et al.* (2020) in ensuring food safety, hygiene practices, such as proper handling, sanitation, and temperature control, must be adhered so as to prevent microbial contamination and the risk of foodborne illnesses**.** While Ogbonna *et al.* (2012) reported that different cut or part of muscles, the effect of nutrient concentration due to moisture loss, higher timing and the temperature which the meat stayed in the fire or excess application of groundnut oil or yaji ,animal statues and locations could influenced the nutritional composition of suya. Despite the popularity and cultural significance of suya production, there are knowledge gaps regarding to the proximate composition and microbial count of suya production in Wukari Metropolis Taraba state. The existing literature provides information on suya production in other states and cities in Nigeria, but no research on the quality of suya produced and sold in Wukari metropolis has been conducted. Therefore, there is a need to assess the quality of suya being produced and sold in Wukari metropolis. The study was aimed at evaluating the proximate and microbial quality characteristics of suya produced in Wukari metropolis.

Materials and Methods

Study area

The study was conducted in Wukari Metropolis and the service of Central Laboratory of Federal University Wukari was used for proximate and microbiology laboratory protocols. Wukari is a well-known city in Taraba state with a significant population that enjoys suya as a popular street food. Wukari is located between latitude 7°52'36.4"N and longitude 9°47'01.8"E. it is situated at an elevation 189 meters (Wikipedia, 2011).The total land mass of Wukari is 4,308km^2 and a population of 241,546 as at 2006 census (World Atlas, 2015). Wukari is recognized for its diverse cultural heritage and traditional food practices (Agbu, 2012)**.**

Collection of Suya samples

Ready to eat suya (grilled meat) samples made from beef were purchased from suya processors. Randomized sampling method was used to collect suya samples from four locations (Hospital, Puje, Avyi and Chonku Wards) within Wukari Metropolis, Taraba State. The samples were stored in tightly sealed containers and kept in refrigerator at 4˚C and analyzed for proximate and microbial counts within 6 - 24 hours of collection. The locations were selected on the basis of availability of suya processors and vendors in these locations. In addition there is slightly difference in method of processing, meat cuts, amount and spices used in the preparation of Yaji in these wards,

Experimental design

A total of 36 suya samples made from beef were randomly collected from the locations. Each of the locations was replicated thrice with three samples of the suya per replicate in a completely randomized design. The samples taken to the laboratory in sterile bags packed in insulated containers with ice packs.

Proximate analysis of suya

Proximate composition of suya such as the moisture content, crude protein, fat, ash and nitrogen free extract contents were determined by the procedure described by (AOAC, 2016). The process started with sample preparation, followed by drying 5 – 10 g of suya sample in an oven at temperature of 105±5°C to a constant weight. Ash content was determined by igniting 1g of suya samples in a Muffle furnace at 500°C for 5 - 6 hours until ashes were produced. While protein was measured using a

nitrogen determination method, such as the Kjeldahl method. Fat was extracted with solvents and quantified gravimetrically.

Microbial count of suya

According to NACMCF (2010), determination of microbial count in suya products involved sampling, homogenization, and isolation of microorganisms using selective agars such as Plate Count Agar (PCA) for bacterial count, Sabouraud Dextrose Agar (SDA) for fungi and MacConkey Agar for coliforms. The prepared agar plates were incubated at specific temperatures (37°C for bacteria, 25-30°C for fungi) for colony growth, and visible colonies were counted. Results were expressed as colony-forming units per gram (CFU/g) for bacteria and molds

Statistical analysis

The mean scores obtained from the proximate analysis and microbial counts were subjected to one-way Analysis of Variance (ANOVA) using completely randomized designs (CRD) and significantly different means were separated using Least Significant Difference (LSD). SPSS software 20 version was used.

Results and Discussion

Proximate composition

The proximate composition of *suya* refers to the percentage of various essential components present in the food. These components include moisture, protein, fat, ash, and carbohydrates (Ijarotimi and Keshinro, 2020). As presented in Table 1, no significant differences ($p>0.05$) were observed in all the parameters analyzed on the *suya* samples across the wards in Wukari Metropolis however numerically, *suya* samples from Avyi ward had highest moisture content (23.36%) while the lowest moisture content was found in the suya sample from Puje ward (14.15%). No significant difference ($p>0.05$) found on the suya samples is an indication that all the *suya* produced in Wukari metropolis are similar in proximate composition or nutritive value despite the locations where its being produced and sold which is an indication that similar meats (beef) or meat cuts were used since the producers got their meats from the same place. It could also be due to similar processing method and ingredients used in suya production. This is in agreement with Ogbonna *et al*. (2012) who reported that processing technology could be responsible for differences in the proximate composition of suya The highest moisture content found in Avyi implies that suya samples are liable for microbial spoilage if not preserved or sold on the day of production since availability of water favors microbial growth and spoilage (Anas *et al*., 2019). While the low moisture content observed in Puje and Chonku ward could be attributed to the high intensity of the fire used during production which helps to reduce the moisture contents and microbial growth, This agreed with Ogbonnaya and Imodiboh (2009), who reported that drying of lean meat of about 20% of moisture inhibits the growth of most bacteria, yeasts and molds while a level of 15% moisture inhibits some species of fungi. The moisture content in this study ranged from 14.15 - 23.36 % is lower than 25.13 - 27.13% moisture content reported by Adomeh and Ogbeifun (2023), 24.64 - 46.32% moisture content reported by Albert *et al*. (2021) and 37.01% reported by Ogbonna *et al.* (2012).

Crude protein is a measure of all the protein in the food through a chemical analysis that measures the amount of nitrogen present as a way of estimating the protein content. The highest crude protein (33.37%) was found in the suya sample from Puje ward while the lowest crude protein content (11.28%) was found in *suya* sample from Hospital ward (Table1). The highest crude protein content found on the *suya* samples from Puje Ward could be attributed to the different parts of muscles which contain different essential amino acids in the meat cuts used in the production. This agrees the report that physicochemical parameters of various meat products depend on the type of meat (Champomier-Verge`s and Zagorec, 2014), More so, Adeyemi *et al*. (2016) reported that the nutritional composition of meat varies depending on the species, meat cut, and production system. The crude protein contents in this study ranged from 11.28 – 33.37% is

higher than 20.57 - 23.32% reported by Adomeh and Ogbeifun, (2023), 8.80 - 17.30% reported by Albert *et al*. (2021) and 32.63% reported by Ogbonna *et al*. (2012). Suya is a protein-rich food due to the meat used as the main ingredient. Proteins are vital for growth, repair, and maintenance of body tissues.

Fat is mainly used to determine the energy value of food products by food processors. The highest fat content was found in suya from Hospital ward (41.44%) while the lowest was found in suya from Avyi ward (15.15%) (Table1). Fat content in suya primarily comes from the marbling of the meat and the oil used in the spice blend. More so Fats contribute to the flavor, aroma, and energy content of the food (Mottram, 1998). The highest fat content found in suya from Hospital ward could be due to the meat cuts or type of muscle, amount of groundnut oil including the yaji used in production. However, the fat content will aid in enhancement of sensory characteristics of the sample since juiciness is related to the fat content of the meat products (Winger and Hagyard, 1994) and. the stimulating effect of fat or fat soluble precursors on salivary flow is believed positively contribute to meat flavour (Fruet *et al.,* 2019). Evidence of significant losses of fat in many meat cuts during broiling, grilling and pan frying without added fat were reported by Grunert *et al*. (2004). Therefore, the low fat content obtained in Avyi Ward could be attributed to the melting and leaching of fats due to higher temperatures implicit in drying and smoking method. Therefore, *Suya* samples from Avyi Ward would be preferred by the consumers who have preference for lower fat content (Youl *et al*., 2012). During cooking, undesirable changes can occur and lead to decrease in the nutritional value, mainly loss of mineral and vitamin and changes in the composition of fatty acid (Rodriguez-Estrada *et al*., 1997). The range of fat content of suya (15.15 – 41.44%) in this study is higher than 21.66 – 26.10% reported by Okonkwo *et al*. (2012), 5.06 - 6.22% reported by Adomeh andOgbeifun, (2023), 5.25 - 8.75% reported by Albert *et al*. (2021) and. 20.90 - 28.26% reported by Ogbonna *et al*. (2012).

As presented in Table 1, *Suya* from Chonku Ward had the highest ash contents (7.47%) while *suya* samples from Puje ward had the lowest ash contents (4.67%) across the wards. This is an indication that *suya* from Chonku ward had more minerals compared to other samples from other wards which could be as a result of the part of muscle and amount of the ingredients being used in the production. This agrees with the report of Elizabeth (1995) that the ash content of any processed meat would be the ash content of the muscle tissue in addition to that of ingredients used. While the lowest ash content found in Puje ward could be attributed to loss of minerals in the samples due to the intensity of the fire from the heat source. This is in agreement that undesirable changes can occur during cooking and lead to decrease in the nutritional value, mainly loss of mineral and vitamin (Rodriguez-Estrada et al., 1997). Minerals serve as the vital elements for skeletal structure; they influence muscle and nerve activity, control the body's hydration balance and are essential parts of hormones, enzymes, and other biologically active substances (Kim and Choi, 2013). The range of ash in this study is higher than the range of 1.80 – 2.86% reported by Okonkwo *et al*. (2012).

The highest nitrogen free extract content (17.64%) was found in the suya sample from Puje ward while the lowest nitrogen free extract content (8.94%) was found in suya from Hospital ward. The nitrogen free extract contents of the suya samples in this study would largely come from the ingredients in Yaji which consist of ground peanuts, ginger, garlic, onion, and various spices such as cayenne pepper and paprika since they are of plant origin which is high in common sugars (Olusola *et al*., 2017). The highest nitrogen free extract content found in the suya sample from Puje Ward is an indication of the proportion of Yaji materials marinated into the meat during processing compare to other suya samples. The range of nitrogen free extract (17.64 – 8.94%) in this study is lower than 52.58 - 55.86% reported by

Adomeh and Ogbeifun (2023). The differences in the proximate parameters across the wards could be due to the different cut or part of muscles used, the effect of nutrient concentration due to moisture loss, higher timing and at the right temperature which the meat stayed in the fire or as a result of excess application of groundnut oil or yaji and animal statues sold in different locations (Ogbonna *et al.*, 2012).

Table 1: Proximate composition of *suya* from Wukari Metropolis

Parameters	Hospital Ward (%)	Puje Ward (%)	Avyi Ward (%)	Chonku Ward (%)	SEM
Moisture	22.05	14.15	23.36	16.7	2.91
Crude protein	11.28	33.37	27.5	22.78	3.46
Fat	41.44	21.35	15.15	26.67	6.01
Crude fibre	9.26	8.83	19.01	16.84	2.04
Ash	7.04	4.67	6.04	7.47	0.55
Nitrogen free extract	8.94	17.64	8.95	9.56	2.68

Microbial counts

Microbial counts indicate the number of bacteria, yeast, and molds present and are used to determine food safety and hygiene. As shown in Table 2, Significant differences ($p<0.05$) were found on microbial counts of *suya* sold in Wukari Metopolis except in fungi. Proteus spp, *Staphylococcus aureaus*, *Bacillus cereus*, *Enterobacter aerogenes* and Fungi (yeast and moulds) were isolated from the *suya* samples. In all the samples analyzed, *suya* samples from Hospital Ward had the highest counts in Proteus spp, *Staphylococcus aureaus*, *Enterobacter aerogenes* and Fungi (4.2788, 5.2989, 4.477, 4.7284 $\log_{10}$ CFU/g) respectively except in *Bacillus cereus* where suya samples from Chonku Ward had the highest count (5.1903 $\log_{10}$ CFU/g) across the suya samples while the lowest count (4.5441 $\log_{10}$ CFU/g) of Fungi was found in Puje ward. Proteus spp was only found in Hospital Ward while Bacillus cereus and Enterobacter aerogenes were not seen in suya from Puje Ward.

Food safety is a critical concern, and microbial count analysis helps assess the presence of microorganisms in food products like suya. The lower microbial counts observed in this study could be due to the addition of Yaji which is of the natural antimicrobials derived from plants, spices, and herbs which has been reported to have potentials to inhibit microbial growth and extend shelf life of suya Adebiyi *et al*. (2020). The contamination of the suya meat product sold in Hospital Ward could be due to poor hygienic practices which led to cross contamination, the use of utensils that were not properly washed and sterilized, untreated water, poor manufacturing practices and improper application of heat (Omotoso *et al*., 2023). The differences in the microbial counts could be linked to the meat quality, processing and dispensing operation and standard of hygiene employed in different wards. The lower microbial counts in Puje Ward could be due to the low moisture content found in Table 1 which inhibits growth of microorganism and also good hygienic practice. The recommended acceptable level of microbial load of ready-to-eat food products falls within a range of 5.4 - 8.0 log10 (Jones *et al*., 2001) whereas London Health Protection Agency (2009) sets less than 10^6 CFU/g as satisfactory limit, and 10^6 to $<10^7$ CFU/g as acceptable range. The acceptable

limits order of $\leq 10^3$ and tolerable limits of 10^4 to 10^5 for total aerobic bacterial and *fungal* counts was reported by (ICMSF, 1996). In addition Health Protection Agency (2009) also reported the acceptable limit of *Staphylococcus aureus* in cooked meat products should not exceed 10^5 CFU/g.

Therefore from the results of this study the suya samples from Wukari Metropolis were found to be safe for consumption since they fall within the recommended acceptable ranged reported by London Health Protection Agency (2009) but the samples from Puje ward were safer since the lowest microbial counts were found in it. The range of mean counts of *Staphylococcus aureus* 4.13 - 5.29 (log CFU/g) in this study is lower than 5.65 (log CFU/g) reported by Ogbonna *et al*. (2012) and 5.00 - 8.40 CFU/g reported by Barber *et al*. (2018) while *Fungi* and *Bacillus* (4.54 – 4.72 and 0-5.19(log CFU/g) are higher than 3.95 and 4.00 - 8.48 (log CFU/g) reported by Ogbonna *et al*. (2012) and Barber *et al*. (2018), respectively.

Table 2: Microbial counts of *suya* produced in Wukari Metropolis (log_{10} CFU/g)

Parameter	Hospital ward	Puje ward	Avyi ward	Chonku Ward	SEM
Proteus spp (log_{10} CFU/g)	4.2788 [a]	0.00 [b]	0.00 [b]	0.00 [b]	3.5051
Staphylococcus aureaus (log_{10} CFU/g)	5.2989 [a]	4.3222 [b]	4.3222 [b]	4.1303 [b]	4.4719
Bacillus cereus (log_{10} CFU/g)	4.1461 [b]	0.00 [b]	4.8543 [ab]	5.1903 [a]	4.4030
Enterobacter aerogenes (log_{10} CFU/g)	4.4771 [a]	0.00 [b]	3.1761 [b]	0.00 [b]	3.8963
Fungi(Yeast and mould) (log_{10} CFU/g)	4.7284	4.5441	4.7033	4.5798	3.6955

CFU/g: Colony Forming Unit per gram, [ab] Means in the same row with different superscripts are significantly different (P<0.05), SEM: Standard Error of Mean

Conclusion and recommendation

In the evaluation of quality characteristics of suya produced in Wukari Metropolis Taraba, State. No significant difference (p>0.05) was observed in proximate composition across the wards however the variations in the proximate parameters across the wards could be due to the effect of nutrient concentration due to moisture loss, higher timing and at the right temperature which the meat stayed in the fire or as a result of excess application of groundnut oil or yaji and animal statues sold in different locations. Significant differences (p<0.05) were found on microbial counts of *suya sold in Wukari Metopolis except in fungi*. Proteus spp, *Staphylococcus aureaus*, *Bacillus cereus*, *Enterobacter aerogenes* and fungi (Yeast and Mould) are microbes that were isolated from the *suya* samples. In all the samples analyzed, *suya* samples from Hospital ward had the highest microbial counts except in *Bacillus cereus where s*uya samples from Chonku ward had the highest count while the lowest microbial counts were found in suya from Puje ward. Therefore suya samples from Wukari Metropolis are safe for consumption since the fall within the recommended value ofless than 10^6 CFU/g as satisfactory limit, and 10^6 to $<10^7$ CFU/g as acceptable range but the suya from Puje ward is safer since the lowest microbial

counts were found in it. It is recommended that the suya producers and vendors should improve their hygiene and sanitation practices to avoid contamination of the product. Consumers should be encouraged to purchase wholesome suya from suya processors in Puje ward since low microbial counts were found from the ward.

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