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Research Article

Effects of Meat Types on Proximate and Microbial Qualities of Suya Produced in Wukari Metropolis, Nigeria

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ABSTRACT

Introduction: Ethnic meat products are traditional meat-based foods that have gained cultural and commercial significance worldwide. Suya is a popular West African ready-to-eat meat product made from skewered and grilled meat in Nigeria. However, concerns about its safety have increased due to the use of poor-quality meat and unhygienic processing practices, which could lead to food poisoning. Therefore, this study assessed the effects of different meat types on the proximate and microbial quality of suya produced in the Wukari Metropolis.
Materials and methods: Four thousand five hundred naira of Suya samples were randomly collected in clean, tightly sealed containers from various Suya processors in Wukari Metropolis. A total of nine suya samples from each meat type (beef, chevon, and mutton) were gathered within the metropolis. The samples were stored at 4˚C for eight hours before conducting proximate and microbial analysis. Plate Count Agar (PCA) was used to measure total viable counts, Eosin Methylene Blue Agar (EMB) for coliform detection, *Salmonella* and *Shigella* Agar (SSA) for pathogenic identification, and Mannitol Salt Agar (MSA), MacConkey Agar, Blood Agar Base, and Potato Dextrose Agar (PDA) for fungal growth analysis.
Results: No significant differences were observed in the proximate composition of suya based on meat type, except for moisture content. Suya made from mutton had the highest moisture content (37.48 ± 1.38%), while suya from beef had the lowest (31.88 ± 1.88%). Suya made from chevon recorded the highest crude protein and ash content at 26.87 ± 0.19% and 7.80 ± 0.53%, respectively, though the variations were insignificant. Similarly, no significant differences were noted in microbial counts across the different suya samples. *Coliform*, *Salmonella*, *E. coli*, *Staphylococcus*, and fungi were isolated from the samples, except for beef-based suya, which showed no presence of *Salmonella*. Despite the microbial presence, the suya samples were deemed safe and nutritious, as their microbial levels fell within the acceptable range of 2.5×10^5 to 1.0×10^8 CFU/g.
Conclusion: The study confirmed that suya produced from different meat types is both nutritious and safe for consumption. However, improved hygiene practices during the production and handling of suya are recommended to ensure better safety and quality in the study area.

1. Introduction

Ethnic meat products refer to traditionally developed meat products which have become culturally and commercially valuable food products in different parts of the world[1]. They can be produced with different types of meat and constitute important elements of the food heritage and ecology of many countries where they have been consumed for centuries[2]. According to Laranjo et al.[3], these traditional meat products are high-sensory quality foods, usually with high nutritional value, produced on a small scale, using ingredients and procedures from ancient times. In Nigeria, the common indigenous ready-to-eat meat products are balangu[4], kilishi[5,6], Danbu nama[7], tsire[8], jirga[9], Kamsa[10,11], ndako, banda and suya[12]. These products are

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highly valued due to their unique flavours[13,14] and cultural significance[15]. They have similar ingredients, but the method of production and the meat used differ from one to another, depending on location and the consumer's choice. Recently, there has been an increase in consumers' concern about the wholesomeness and safety of these products due to the status of animals which affects the meat quality, unhygienic and poor sanitary practices during the production and retail of the products which adversely affect their microbiological quality and hence pose a health risk to the public[4,16-18]. These led to the study of the safety and quality of suya produced from different meat.

Suya is a popular West African street food made from skewered and grilled meat[19]. It is a meat product that is rich in nutrients such as protein, fats, minerals, and vitamins[20]. Suya originated in the Northern parts of Nigeria[21], but it has permeated the society because of its affordability and availability. It is typically prepared from skewered pieces of beef seasoned with a spicy peanut-based marinade and then grilled[17]. Other meats can be used in its production, but beef is most preferred because rearing of cattle is predominantly known among the northerners and their major source of livelihood[21]. Suya has been called a unifying factor in Nigeria[22] because it is the most common ready-to-eat meat product among Nigerians[23]. Due to these attributes, an increase in the demand for suya in Nigeria was observed[24,] and it's due to factors such as increased population[25], cultural significance[26], its taste and flavor[27], convenience[28,] and health considerations[29]. The continuing production of suya as a sustainable venture for meat processors depends on their ability to provide nutritious, wholesome, and safe products to the consumers[30]. Concern about the safety of suya for consumption has greatly increased due to the unwholesome meat and unhygienic practices employed during its production[18]. Hence, quantitative studies on the proximate composition and microbial load of suya products produced in different cities and states have identified suya as a dense, nutritious snack and a possible source of food poisoning[16-18,20,31-34]. However, little or no research has been conducted on the qualities of suya produced from different meats in Wukari Metropolis, Taraba State. Therefore, there is a need to evaluate the microbial and nutritional quality of suya produced from different meats in the Wukari metropolis. This will provide database line information and bridge the knowledge gap of the nutritional and safety of suya produced from different meats in Wukari Metropolis. Hence, the study aims to evaluate the effects of meat types on the proximate and microbial qualities of Suya produced in the Wukari Metropolis.

2. Materials and Methods

The study was conducted in Wukari Metropolis. Wukari is a well-known city in Nigeria, located in Taraba State, with a significant population that enjoys suya as a popular street food. The city's geographical coordinates are latitude 7°52'36.4"N and longitude 9°47'01.8"E. The total land area of Wukari was 4,308 km^2, and it had a population of 241,546 as of the 2006 census[35]. The vegetation of the area is predominantly characteristic of the savannah zone, with major climatic seasons of wet or rainy seasons, which start in March or April and end in October, and the dry season, which starts in November and ends in March or April. The average rainfall is about 1350 mm, and the average temperature is 26.8ºC[36]. Wukari is recognized for its diverse cultural heritage and traditional food practices[37].

2.1. Collection of suya samples

Ready-to-eat suya samples of four thousand five hundred naira (Nigerian currency) were randomly collected in clean plastic, tightly sealed containers from different suya processors in different wards (Puje, Avyi, Hospital, and Chonku). A total of 9 samples of suya for each of the meat types (beef, chevon, and mutton) were collected within Wukari Metropolis, Taraba State. The samples were stored in tightly sealed containers and kept in the refrigerator at 4˚C for 8 hours for proximate and microbial analysis.

2.2. Proximate analysis

The proximate composition of suya, such as the moisture content, crude protein, fat, ash, and nitrogen-free extract contents, was determined according to the procedure described by AOAC[38]. The process started with sample preparation, followed by drying to a certain moisture level. Ash content was determined by incineration while protein was measured using a nitrogen determination method, such as the Kjeldahl method ISO 20483[39]. Fat was extracted with solvents and quantified gravimetrically.

2.3. Microbial analysis

This was done according to the procedure described by Buhari et al.[40]. Using a sterile knife, 10 g of the sample was cut and transferred aseptically into 90 mL of 0.1% sterile peptone water. It was allowed to soak for about 10 minutes, after which 1 mL was transferred into a bottle containing 0.1 % sterile peptone water (10^{-1}) dilution. This was severely diluted with a 10^{-7} dilution and obtained with the aid of a sterile pipette. 0.1 mL of 10^{-5} dilution was aseptically transferred onto the surface of an agar Plate Count Agar (PCA) used for total viable counts, Eosin methylene blue agar (EMB) was used for *coliform*, *Salmonella* and *Shigella* agar (SSA) for pathogenic detection, mannitol salt agar (MSA) Macconkey agar, blood agar base and potato dextrose agar plates (PDA) for fungal growth and were spread evenly on the surface by using a spreader respectively. The plates were then incubated at 37 ˚C for 24 hours. At the end of the incubation period, the bacterial and fungal colonies grown on both media were counted and the result was expressed as colony forming unit per gram (CFU/g) by using the formula[41]:

$$CFU/g = \frac{Total\ number\ of\ colonies\ counte}{volume\ of\ inoculate \times Dilution\ factor}$$

2.4. Statistical analysis

The data was statistically analyzed using one-way Analysis of Variance (ANOVA), and significantly different means were separated using Least Significant Difference (LSD). SPSS software version 20 was used at a 5% level of probability.

3. Results

3.1. Effects of meat types on proximate composition

Effects of meat types on the proximate composition of suya produced in Wukari Metropolis, presented in Table 1, showed no significant differences across the suya samples ($p > 0.05$) except for moisture content, where a significant difference was only observed ($p < 0.05$). Suya produced from mutton significantly ($p < 0.05$) differs from other suya samples in moisture content. The highest moisture content (37.48 ± 1.38%) was found in suya produced from mutton, followed by suya produced from chevon (33.85 ± 1.96%), while the lowest moisture content (31.88 ± 1.88%) was found in suya produced from beef. Although there were no significant differences in other proximate parameters however, numerically the highest crude protein, ash, and carbohydrate contents (26.87 ± 0.19, 7.80 ± 0.53 and 10.95 ± 7.72 %) were found in suya made from chevon respectively compared to other suya samples while the highest fat content (19.95 ± 6.88%) was found in suya made from beef and the lowest fat content (15.65 ± 6.69%) was recorded in suya produced from chevon across the samples.

Table 1. Effects of Meat Types on Proximate Composition of Suya Produced in Wukari Metropolis of Taraba State, Nigeria in 2024

Parameters	Suya produced from beef (%)	Suya produced from chevon (%)	Suya produced from Mutton (%)	P-Value
	Mean± SD	Mean± SD	Mean± SD	
Moisture	31.88±1.88^{b}	33.85±1.96^{b}	37.48±1.38^{a}	0.02
Crude protein	25.59±1.04	26.87±0.19	25.80±1.18	0.26
Fat	19.95±6.88	15.65±6.69	19.00±3.06	0.65
Crude fibre	4.87±0.31	3.22±2.79	5.02±0.05	0.38
Ash	7.61±1.70	7.80±0.53	7.73±0.49	0.98
Carbohydrate	10.10±3.59	10.95±7.72	3.28±0.31	0.19

Results represent Means ± Standard Deviation (SD), ^{abc} Means with different superscripts along the same rows show significant differences at ($p < 0.05$)

3.2. Effects of meat types on microbial counts

Table 2 showed no significant difference in the effects of meat types on microbial counts of suya produced in Wukari Metropolis ($p > 0.05$). However, microbes such as *Salmonella*, Fungi, *Staphylococcus*, *coliform*, and *Escherichia coli* were isolated from the suya samples. Variations that were not significantly different were found on suya produced from beef, having the highest total bacteria of $3.65\times10^2 \pm 364.2$ CFU/g ($p > 0.05$). While suya produced from mutton had the highest counts ($8.40\times10^2 \pm 150.2$ and $6.21 \times10^2 \pm 259.4$ CFU/g) for total coliform and fungi, respectively. Additionally, *Salmonella* was absent in suya produced from beef, while the highest *Salmonella* and *Escherichia coli count* ($1.68 \times10^2\pm361.1$ and $1.63 \times10^2\pm139.2$ CFU/g) were found in suya produced from chevon. The Total Bacteria Count (TBC) in this study ranged from $2.20 \times10^2 \pm 90.55$ - $3.65\times10^2 \pm 364.2$ CFU/g.

Table 2. Effects of meat types on microbial counts of suya produced in Wukari Metropolis of Taraba State, Nigeria in 2024

Parameter	Suya produced from beef (CFU/g)	Suya produced from chevon (CFU/g)	Suya produced from Mutton (CFU/g)	P-Value
	Mean± SD	Mean± SD	Mean± SD	
Total bacterial count	$3.65\times10^2\pm36.2$	$2.20 \times10^2\pm90.55$	$2.73 \times10^2\pm154.1$	0.56
Total Coliform	$6.16 \times10^2\pm223.8$	$6.50 \times10^2\pm164.6$	$8.40\times10^2\pm150.2$	0.10
Salmonella	0.00	$1.68 \times10^2\pm361.1$	$1.31 \times10^2\pm109.1$	0.39
Fungi	$3.23 \times10^2\pm308.7$	$2.65 \times10^2\pm313.2$	$6.21 \times10^2\pm259.4$	0.11
Staphylococcus	$4.06 \times10^2\pm217.1$	$5.03 \times10^2\pm294.3$	$2.23 \times10^2\pm78.40$	0.11
Escherichia coli	$0.73 \times10^2\pm82.62$	$1.63 \times10^2\pm139.2$	$1.36\times10^2\pm120.4$	0.41

Results represent Means ± Standard Deviation (SD)

4. Discussion

4.1. Effects of meat types on proximate composition

Proximate composition refers to the analysis of the basic macronutrients and components that make up a food or biological sample. It provides a breakdown of the major constituents, typically expressed as a percentage of the total mass[39]. Water is one of the important constituents of all food materials. The significant variations found in moisture content with suya produced from mutton having the highest content (Table 1) could be due to the variations in the moisture content of the different meats used, the grilling period, and the intensity of the fire used by the processors during their production. This agrees with the report that the differences in the proximate composition of suya could be the processing technology[18]. The moisture content found in this study showed that the suya samples were not a staple food. According to Ahmad et al.[41] stable food materials have less than 15% moisture content. Therefore, the suya samples are prone to microbial spoilage if not consumed immediately after production or preserved by refrigerating. This is in agreement with the report of Azad et al.[42] that the higher the water contents of any food material, the shorter its shelf life due to invasion by micro-organisms, which reduce their quality and shelf life. However, an increase in the moisture content could enhance their sensory qualities. According to Mir et al. [43,] moisture content affects the color, texture, and flavor of the muscle tissues of meat. The range of moisture content found in this study is similar to the range of 36.65 – 39.09% reported by Ogbonna et al.[18], but lower than the 41 % reported by Salihu et al.[44]. However, it is higher than 22.75 - 23.11% reported by Ayanniyi et al.[45] and within the range of 28.31 - 47.76% reported by Ahmad et al.[46].

Proteins are naturally occurring complex nitrogenous compounds having a very high molecular weight consisting of carbon, hydrogen, oxygen, and most importantly, nitrogen[47]. No significant difference ($p > 0.05$) was found in the crude protein content of the suya samples, implying that the different meats used in suya production had similar crude protein contents and the crude protein content was not affected by the meat types. The little variation and higher crude protein found in suya produced with mutton could be attributed to the amount of the spices used which could add its crude protein content to the suya sample while the numerical reduction in suya produced from beef and chevon could be attributed to the leaching of soluble proteins due to increase in intensity of the heat during processing. Young et al.[48] reported that heating of meat and meat products causes muscle proteins to denature, and the production process can lead to the loss of some soluble proteins[49]. Processing of meat to suya aids in enhancing the protein content of raw meat by adding value to it. According to Naclerio et al.[50] protein content of beef ranges between 18 – 25 %, while the range of 16 – 22% and 20 – 28 % was obtained in mutton and chevon, respectively. These values are lower than the value of protein found in suya[51,52]. It implies that suya is a good source of protein because, according to WHO[52] estimated average daily protein requirement for an adult is 52.5 g. Protein is essential for muscle growth, repair, immune function, and overall cell health[53]. The range of crude protein found in this study is higher than 8.83 ± 0.58 % reported by Nworu et al.[54] and 8.21 - 16.88 % reported by Ahmad et al.[46], but lower than 29.51 % reported by Salihu et al.[44] and the range of 28.33 – 35.10 % reported by Ogbonna et al.[18].

The fat content of meat functions as energy deposits, protective padding in the skin and around organs, especially the heart and kidneys as well as provides insulation against body temperature losses[47]. No significantly lower fat content found in suya produced from chevon could be attributed to the differences in the fatty acid composition of fatty tissues of the meat since the range of fat content (3 - 5%) of chevon[55,56] is lower than 5 - 10% of beef [53] and 6 - 15% of mutton[56,57]. This agrees with the report of Ahmad et al.[41] that there are significant differences in the fatty acid composition of fatty tissues in different locations in poultry and other animals. In addition, Champomier-Verge et al.[57] also reported that the physicochemical parameters of various meat products depend on the type of meat. Furthermore, it could be due to the intensity of the grilling process. This agrees with Grunert et al.[58] who reported significant losses of fat in many meat cuts during broiling, grilling, and pan frying without added fat. However, the suya produced by chevon could be preferred by consumers who like low-fat products and have a bias against foods that are high in fat due to health-related issues related to animal fat consumption[59,60]. Higher fat content found in samples of suya produced from beef and mutton is expected to enhance flavor and juiciness, and hence the acceptability of the products[61]. The range of fat content recorded in this study is similar to 19.30 % reported by Salihu et al.[44] but higher than 5.22 – 8.75 % reported by Ayanniyi et al.[45] and lower than 20.54 ± 4.0 % reported by Nworu et al.[54] and 20.90 – 28.26 % reported by Ogbonna et al.[18].

Furthermore, according to AOAC[62] ash content of a material is the inorganic residue remaining after the organic matter has been destroyed by combustion in the muffle furnace. Minerals are the nutrients present in food materials that do not contain the element carbon in them and are required for the proper growth, development, as well as maintenance of the human body[63]. The similar ash content found across the samples is an indication that all the suya samples are good sources of minerals. The ash content is not affected by the different meats but rather by the spices used during production. This agrees with the report of Elizabeth[64] that the ash content of any processed meat would be the ash content of the muscle tissue, including that of the ingredients used. The range of ash contents in this study is higher than the 6.61 % reported by Salihu et al.[44] range of 1.80 - 2.86 % reported by Ogbonna et al.[18], 4.57±0.10 % reported by Nworu et al.[54], 6.61 % reported by Salihu et al.[44] but lower than 24 – 46 % reported by Ahmad et al.[46].

Meat has little or no crude fiber. Therefore, the low crude fiber found across the suya samples could be attributed to the spices used during production, since they are of plant origin, which is high in common sugars[65]. The range of crude fiber in this study is within the range of 0.99 – 13.58 % reported by Ahmad et al.[46]. Similarly, meat has little carbohydrate, however, the carbohydrate contents found across the suya samples are from the spices used. The lower carbohydrate content found in suya made from mutton could be attributed to the higher amount of spices used during production. Carbohydrates are the main source of energy in humans, and the range found in this study is higher than the range of 1.05 - 2.74 % reported by Ahmad et al.[46].

4.2. Effects of meat types on microbial counts

The microbial counts of any meat product reflect the level of microbial contamination present, which can indicate the food's safety and quality. No significant difference found across the suya samples is an indication that the different meats used have no significant effect on the microbial load of the suya samples; rather, the microbial load could be from the environment, unhygienic handling practices, or poor sanitary conditions, and inadequate cooking temperatures[12,66-69]. The absence of *salmonella* found in suya produced from beef could also be attributed to proper hygiene practices or proper handling practices during production, compared to other suya samples. Despite the presence of microbes isolated in this study, the suya samples had lower microbial counts, safe for consumption, and did not pose any health risk since they fall within the recommended range of less than 10^6 CFU/g as a satisfactory limit and 10^6 to $<10^7$ CFU/g as an acceptable range[70]. Additionally, the acceptable limits of $\leq 10^3$ and tolerable limits of 10^4 to 10^5 for total aerobic bacterial and fungal counts were reported by the International Commission on Microbiological Specifications for Foods[71]. For ready-to-eat foods, the Commission recommended a range limit of 2.5×10^5 - 1.0×10^8 CFU/g for consumable meat products. The study is in agreement with the report of Ike and Ogwuegbu[12] that isolated *Escherichia coli*, *Salmonella species,* and *Staphylococcus aureus* from locally processed suya sold in Owerri metropolis, Imo State, Nigeria. Ogbonna et al.[18] also reported isolation of *Escherichia coli*, *Salmonella,* and *Shigella* in suya samples from Maiduguri, Northern Nigeria. Omotoso et al.[68], Adeleye et al.[71] also reported that *Staphylococcus spp*, *Escherichia coli*, *Bacillus sp*, *Salmonella,* and *Klebsiella sp*. were the most identified bacterial contaminants in suya. The range of coliform and *fungi* counts in this study is within the range of $0.5\text{x}10^1 \pm 0.13 - 1.5\times10^2 \pm 0.10$ and $3.9\times10^1 \pm 0.08 - 1.3 \times10^3 \pm 0.14$ CFU/g of coliform and *fungi* counts reported by Ike and Ogwuegbu[12], respectively. But lower than 5.83×10^3 CFU/g of coliform count reported by Salihu et al.[44]. In addition, the range of total bacterial count in this study is lower than 2.14×10^5 CFU/g reported by Salihu et al.[44], which is an indication that the suya samples were done in poorer, unhygienic practices compared to those of this study.

5. Conclusion

In the study of the effects of meat types on proximate and microbial qualities of suya produced in Wukari Metropolis, no significant difference was observed in the effects of meat types on proximate composition across the suya samples except on moisture content where a significant difference was observed. Suya produced from mutton had the highest moisture content (37.48 ± 1.38%) while the lowest moisture content was found in suya produced from beef (31.88 ± 1.88%). Furthermore, no significant differences were found in the effects of meat types on microbial counts across the suya samples. However, microbes such as *Coliform*, *Salmonella*, *E. coli*, *Staphylococcus*, and Fungi were identified and isolated from the suya samples except on suya produced from beef where *Salmonella* was absent. However, despite the isolation of these microbes the suya samples were fit for consumption and do not pose any health risk since they fall within the recommended acceptable range of 2.5×10^5 - 1.0×10^8 CFU/g. Therefore, the study implies that the meat types (beef, chevon, and mutton) have similar effects on the proximate and microbial qualities of the suya produced in Wukari Metropolis. They are nutritious, safe for consumption, and do not pose any health risk to the public. Nevertheless, proper hygiene practices and sanitary conditions in the production and handling of the suya should be improved in the study area.

Declarations

Competing interests

There is no conflict of interest.

Authors' contributions

Research conceptualization and design, supervision, drafting of the article, review, and editing was done by Iyiola Vivian Ogechi while the acquisition of data, methodology, data validation, and analysis was carried out by Danladi Philip, and Aladi Nnanyere also participated in writing, reviewing, and editing. Msughter Gloria contributed to the acquisition of data or analysis. All authors gave final approval of the version to be published and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Availability of data and materials

The data and materials can be made available to the community

Ethical considerations

We declare that we have observed ethical issues, including plagiarism, double submission, and data originality.

All protocols adhered to the ethical approval by the Board of Examiners of the Department of Animal Production and Health, Federal University Wukari, Taraba State, Nigeria.

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