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Research Article

Microbial quality and shelf-life stability of chicken suya treated with selected natural antioxidants and packaged in different materials

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Abstract

Chicken suya is a popular ready-to-eat meat product in Nigeria; however, poor handling, processing, and storage conditions may compromise its microbiological quality and pose potential health risks to consumers. The use of natural antioxidants and appropriate packaging materials may help improve the microbial stability of suya during storage. This study therefore evaluated the microbial quality and shelf-life stability of chicken suya treated with selected natural antioxidants and packaged in different materials. Sixteen table-sized broiler chickens with an average live weight of 2.5 kg, raised on basal diets, were used for the study. Suya was prepared using ginger, red pepper, white pepper, groundnut oil, salt, seasonings, and groundnut cake powder, with Alligator Pepper (AP), Black Pepper (BP), and Ethiopian Pepper (EP) used as alternative spice treatments. The prepared suya samples were packaged using foil paper, old newspaper, and transparent disposable packaging and stored for 0 and 30 days. Microbial quality was assessed based on Total Bacterial Count (TBC), Total Coliform Count (TCC), and Total Yeast Count (TYC). Data obtained were subjected to analysis of variance appropriate for the factorial experimental design, and significant differences were determined at the 5% probability level. The results showed that the highest TBC (7.81×10^6 cfu/g) was recorded in the control treatment, whereas suya treated with Ethiopian Pepper had the lowest TBC (5.34×10^6 cfu/g). Similarly, the highest TYC (3.99×10^3 cfu/g) was observed in the control, while the lowest TYC (2.46×10^3 cfu/g) was recorded in suya treated with Alligator Pepper. Packaging material also influenced the microbial quality of the product, with foil paper and transparent disposable packaging showing better potential for reducing microbial loads than old newspaper packaging.

In conclusion, this study shows that selected natural antioxidants, especially Ethiopian Pepper and Alligator Pepper, in conjunction with appropriate packaging materials, can improve the microbial quality and storage stability of chicken suya.

Introduction

Meat and its products are important components of human nutrition because they provide high-quality proteins, essential amino acids, fats, minerals and vitamins (Zhang et al., 2010). However, their high nutrient content and relatively favorable moisture conditions also make them susceptible to microbial contamination and spoilage. Consequently, preservation of meat products is important for maintaining microbiological quality, ensuring food safety and extending shelf life. Traditional preservation methods such as salting, drying, smoking, fermentation and heat processing have long been employed to inhibit microbial growth and delay deterioration of meat products (Sadakuzzaman et al., 2024; Dave et al., 2011).

Suya is a popular traditionally processed, ready-to-eat meat product widely consumed in Nigeria. It is a spicy, barbecued, smoked or roasted meat product that originated among the Hausa people of northern Nigeria and has subsequently gained popularity across different parts of the country (Inyang et al., 2005). It is commonly prepared from boneless meat and sold in streets, restaurants, club houses, parties, picnics and other public places (Abdullahi et al., 2004; Omojola et al., 2004). The popularity of suya is largely associated with its distinctive flavor, convenience and instantly consumable in nature. However, the traditional methods employed in its preparation, handling, transportation and storage may expose the product to microbial contamination.

The microbiological safety of suya is of particular concern because the product may be subjected to several potential sources of contamination during processing and post-processing handling. These include contaminated water, utensils and processing equipment, unhygienic handling practices, exposure to flies and dust, contaminated spices, transportation and contact with contaminated surfaces (Igyor et al., 2005). In addition, inadequate storage and handling after roasting may provide opportunities for microbial proliferation. Microbial growth in meat products can result in undesirable changes in appearance, texture, flavor and other organoleptic characteristics as microorganisms produce metabolic by-products during spoilage (Jackson and McGowan, 2001). Therefore, measures capable of reducing microbial contamination and maintaining the microbiological quality of suya during storage are necessary.

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Natural antioxidants have attracted increasing interest as potential alternatives or complements to synthetic food preservatives. Antioxidants derived from plants, including spices such as ginger and peppers; contain bioactive compounds that may exhibit antioxidant and antimicrobial activities (Hassan et al., 2026; Shohiduzjamanet al., 2024; Biplob et al., 2024; Akter et al., 2022;; Khatun et al., 2022; Mostafa et al., 2025). Their incorporation into meat products may therefore contribute to the control of deterioration and improvement of product stability (Fasseas et al., 2008; Zhang et al., 2016). Selected spices such as Alligator Pepper, Black Pepper and Ethiopian Pepper are traditionally used as food ingredients and possess phytochemical constituents that may influence the microbial stability of meat products. However, their effectiveness in chicken suya, particularly in combination with different packaging materials during storage, requires further investigation.

Packaging is another important factor influencing the microbiological stability of ready-to-eat meat products. Packaging materials serve as a barrier against environmental contamination and can influence the conditions under which microorganisms survive or multiply. However, the use of inappropriate or unhygienic packaging materials may introduce contaminants into ready-to-eat foods. In particular, the use of old newspapers and other previously used paper materials for wrapping processed meat products may constitute a potential source of contamination (Hasapidou et al., 2011). In contrast, packaging materials of appropriate quality and stability can provide protection against contamination and help maintain product quality during storage (Mostafa et al., 2026; Ingrao et al., 2015). Materials commonly used in meat packaging include aluminum foil and synthetic polymers such as polyethylene, polypropylene, polyvinyl chloride, polyester and polyamide, which are selected according to their functional barrier and protective properties (Cenci-Goga et al., 2020).

Although previous studies have highlighted the importance of hygienic processing, natural antioxidants and appropriate packaging in maintaining the quality of meat products, limited information is available on the combined influence of selected natural antioxidant treatments and commonly used packaging materials on the microbial quality of chicken suya during storage (Akinwumi et al., 2022). This is particularly relevant in Nigeria, where suya is frequently prepared and sold as a ready-to-eat product and where traditional packaging practices remain common. Understanding how natural antioxidant treatments interact with packaging materials could provide useful information for improving the microbiological safety and storage stability of chicken suya (Ganiyu et al., 2026).

Therefore, this study evaluated the effects of selected natural antioxidants and packaging materials on the microbial quality and shelf-life stability of chicken suya during storage. Specifically, the study assessed the total bacterial, coliform and yeast counts of chicken suya treated with Alligator Pepper, Black Pepper and Ethiopian Pepper and packaged using foil paper, old newspaper and transparent disposable packaging during storage.

Materials and Methods

Experimental Site

The experiment was carried out at the Poultry Unit of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso Oyo State, Nigeria. Ogbomoso is located in the derived savanna zone of Nigeria. It lays on longitude 4º 15′ East of the Greenwich Meridian and Latitude 8º 15′ North of the Equator. The altitude is between 300m and 600m above sea level while the mean temperature and annual rainfall are 27ºC and 1,247mm respectively (Ayinla and Odetoye, 2015).

Experimental Samples

Sixteen (16) table size broiler chickens (6 weeks old) with an average live weight of 2.5kg raised on basal diet at the Poultry Unit of Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State were used for this study.

Procurement and Processing of Test Ingredients

The ingredients used in preparation of suya meat were ginger, red pepper, white pepper, groundnut oil, salt, seasonings, and groundnut cake powder. They were purchased from Oja Jagun a commercial market in Ogbomoso, Oyo State. The test ingredients that were used as replacement for suya spices production are Alligator pepper (*Aframomum melegueta*), Black pepper (*Piper nigrum*) and Ethiopian pepper (*Xylopia aethiopica*). The test ingredients were dried and ground into powder form.

Suya Preparation

Dressed chicken carcasses were washed and cut into different parts: thigh and breast. The ingredients were spread on a clean, dry tray and each sheet of meat was properly dusted and soaked with the ingredients. The sticks of meat were labelled and about 5–10 ml of groundnut oil was sprinkled on each meat stick before roasting. The meat was allowed to stay on the charcoal fire at 90°C for 20 minutes with the distance of 22–23 cm from the center of the fire and intermittent turning of the product. Additional groundnut oil was sprinkled on the meat while roasting continued. The ingredients composition as described in Table 1, were used for the production of suya while the conventional pepper (white and dried pepper) was replaced with Alligator pepper, Black pepper and Ethiopian pepper.

Table 1: Ingredient's composition of spices and condiments for chicken suya

Ingredient Common name	Ingredient Scientific name	Control (%)	Alligator pepper (%)	Black pepper (%)	Ethiopian pepper (%)
Groundnut powder	Arachis hypogaea	52.00	52.00	52.00	52.00
Ginger	Zingiber officinale	10.00	5.00	5.00	5.00
Dried pepper	Allium sativum	10.00	___	___	___
White pepper	Capsicum annuum	5.00	___	___	___
Salt	Sodium chloride	8.50	8.50	8.50	8.50
Curry	Murray koenigii	5.00	5.00	5.00	5.00
Maggi seasoning		7.50	7.50	7.50	7.50
Groundnut oil		2.00	2.00	2.00	2.00
Alligator pepper	*Aframomum melegueta*		20.00		
Black pepper	*Piper nigrum*			20.00	
Ethiopia pepper	*Xylopia aethiopica*				20.00
Total			100.00	100.00	100.00

Source: as modified by Akinwumi et al. (2022)

Data collection

The Microbial Analysis

Data on the microbiological quality of chicken suya were collected at 0 and 30 days of storage. Representative samples were aseptically collected from each combination of natural antioxidant treatment and packaging material. The microbial quality of the samples was assessed based on Total Aerobic Count (TAC) and Total Coliform Count (TCC).

For microbial enumeration, representative portions of the suya samples were aseptically collected, homogenized in sterile normal saline and serially diluted. Appropriate aliquots of the dilutions were inoculated onto Nutrient Agar and MacConkey Agar for the determination of TAC and TCC, respectively. The inoculated plates were incubated at 37°C for 24 hours, following established microbiological procedures described by ICMSF (1990), APHA (1992), and AOAC (1995). Following incubation, visible colonies were counted and the microbial load was calculated and expressed as mean colony-forming units per gram (CFU/g).

Statistical Analysis

Data obtained were subjected to analysis of variance using SAS (2002) where statistical significance was observed, the means were compared using the Duncan Multiple Range test of the same statistical software.

Results And Discussion

Effect of natural antioxidants and packaging materials on microbial count of suya from broiler chickens' meat

Effect of natural antioxidants and packaging materials on microbial count of suya from broiler chickens' meat results are presented in Table 4.5. The different natural antioxidants significantly ($p<0.05$) influenced suya on treatments and packaging materials. At the main effect, suya spiced without natural antioxidant (control) had the highest ($p<0.05$) (7.81 cfu/g x 10x6) total bacillus count (TBC) and suya spiced with Ethiopian pepper had the lowest (5.34 cfu/g x 106) loads for TBC. The highest (3.99 cfu/g x 103) total yeast count (TYC) was observed in suya in control treatment, and there was statistically similar value for suya spiced with different natural antioxidant with the lowest (2.46 cfu/g x 103) TYC observed in suya spiced with alligator pepper. Suya packaged with transparent disposable packaging had the highest (5.25 cfu/g x 104) total coliform count (TCC) value and suya packaged with newspaper having the least (4.52 cfu/g x 104) TCC.

Table 2: Effect of natural antioxidants and packaging materials on microbial counts of suya from broiler chicken's meat

Parameters	TBC (cfu/g x 10^6)	TCC (cfu/g x 10^4)	TYC (cfu/g x 10^3)
Treatments			
Control	7.81^{a}	4.90	3.99^{a}
Black pepper	6.15^{b}	4.93	2.75^{b}
Alligator pepper	5.87^{bc}	4.50	2.46^{b}
Ethiopian pepper	5.34^{c}	4.49	2.56^{b}
P-value	0.00	0.20	0.00
SEM	0.45	0.19	0.34
Packaging Materials			
FPP	6.63	4.96^{ab}	3.40
WNP	6.83	4.52^{b}	3.09
TDP	7.50	5.25^{a}	3.63
P-value	0.49	0.04	0.65
SEM	0.50	0.15	0.39

^{abcdef} Means on the same colum with different superscript are significantly ($P<0.05$) influenced
TBC: Total bacteria count TCC: Total coliform counts TYC: Total yeast count
FPP- Foil Paper Packaging, WNP- Wrapping Newspaper Packaging and TDP- Transparent Disposable Packaging.

Interaction effects of natural antioxidants and different packaging materials on microbial counts of suya from broiler chicken's meat

Interactions of natural antioxidants and different packaging materials results on microbial count of suya from broiler chicken's meat are presented in Table 4.6. Suya without natural antioxidants packaged with plastic (control plastic) had the highest ($P<0.05$) (8.61 cfu/g × 106) total bacteria count (TBC). However, suya without natural antioxidants packaged with either foil paper (control foil paper) or newspaper (control newspaper) had similar values (7.52 and 7.33 cfu/g × 106), and were higher ($P<0.05$) than those suya spiced and packaged in other treatment groups. Suya spiced with Ethiopian pepper and packaged with

newspaper (Ethiopian pepper newspaper) had the lowest (P<0.05) (4.99 cfu/g × 106) TBC. Control plastic (4.29 cfu/g × 103) and control foil paper (4.28 cfu/g × 104) were higher and statistically similar for total yeast count (TYC) for suya, while suya spiced with alligator pepper packaged with either plastic (alligator pepper plastic) (2.42 cfu/g × 103) or newspaper (alligator pepper newspaper) (2.08 cfu/g × 103) were lowest.

Table 3: Interactions effects of natural antioxidants and packaging materials on microbial count of suya from broiler chicken's meat

Parameters	TBC (cfu/g × 10^6)	TCC (cfu/g × 10^4)	TYC (cfu/g × 10^3)
Control TDP	8.61^{a}	5.28	4.29^{a}
Control FPP	7.52^{b}	5.00	4.28^{a}
Control WNP	7.33^{b}	4.42	3.43^{ab}
Black pepper TDP	6.40^{c}	5.22	2.98^{bc}
Black pepper FPP	5.73^{cde}	4.94	2.53^{bc}
Black pepper WNP	6.33^{cd}	4.62	2.75^{bc}
Alligator pepper TDP	5.55^{ef}	4.28	2.42^{c}
Alligator pepper FPP	6.42^{c}	4.55	2.88^{bc}
Alligator pefdcddpper TDP	Wdsw2 daZz	4.67	2.08^{c}
Ethiopian pepper TDP	5.81^{cde}	4.86	2.67^{bc}
Ethiopian pepper FPP	5.22^{ef}	4.34	2.53^{bc}
Ethiopian pepper WNP	4.99^{f}	4.22	2.76^{bc}
P-value	0.0001	0.35	0.0001
SEM	0.15	0.23	0.23

^{abcdef} Means on the same columu with different superscript are significantly (P<0.05) influenced
TBC: Total bacteria count TCC: Total coliform counts TYC: Total yeast count
FPP- Foil Paper Packaging, WNP- Wrapping Newspaper Packaging and TDP- Transparent Disposable Packaging

Discussion

The inclusion of natural antioxidants in suya revealed decreases in the total bacteria count (TBC) and total yeast counts (TYC). The reduction in TBC and TYC of suya from broiler meat spiced with natural antioxidants agreed with the observation of Akinwumi et al. (2022) that suya prepared with natural antioxidants had reduced total bacteria count, total coliform count and total yeast count. The author reported that suya prepared with clove had the least microbial count values when compared to control. According to Kamala-Kumari et al. (2019) natural antioxidants have tendencies to reduce mip crobial growth, lipid peroxidation and improve product shelf-life. Egbeyale et al. (2021) also suggested that plants extract have potentials to promote beneficial strains of bacteria due to their antimicrobial properties. According to Ohimain et al. (2015) phytochemical components such as alkaloids and saponins pose antibacterial properties, and may be responsible for the reduction in bacteria counts observed in suya meat. Ilondu et al. (2001) reported that some plants contain phenolic substances and essential oils, which are inhibitory to microorganisms. El astal et al. (2005) documented that the bioactive compounds like tannins and phenols present in Ethiopian pepper are active against bacteria, pests or fungi.

Food packaging is one of the technologies that control microbial growth and maintain product quality (Mansouripour et al., 2013). In addition to modified atmosphere packaging, modern technology has added numerous types of metal, glass, plastic and paper packaging. Generally, packaging improves food safety by protecting the food from contamination (Nwafor and Ikenebomeh, 2009). Suya packaged with plastic had the highest total coliforms count. Possible explanation could be as a result of unclean packing materials, which will increase the bacterial burden. These packaging materials could be a source of microbiological contamination (Owuna et al., 2015). Considering the processing preparation method of suya, there could involve a lot of handling during and after preparations. Each of them increased the possibility of microbial contamination of suya. (Agbo et al., 2016). The principal roles of packaging are to protect food products from outside influences and damages, to contain the food, and to provide consumers with ingredient and nutritional information (Coles, 2003). However, with the wide application of plastic packaging material in food packaging field due to its unique property such as non-poisonous, flexibility, portability, and light weight, food safety caused by plastic packaging material has worried the user due to the existence of various additives (such as odour compounds, plasticizer, and crosslinking agent, etc.) in plastic packaging materials and the impact of air humidity and temperature on these plastic packaging materials (Zhou et al., 2022).

The interaction of packaging and treatment effects shows that different packaging materials and natural antioxidants reduce the microbial counts of suya from broiler meat. Natural antioxidants have abilities to retard microbial growth, lipid oxidation and prolong product shelf life (Kamala-Kumari et al., 2019) which was evident in this study. The choice of suya packaging material significantly influences its microbial content, making it essential to select the right packaging material and handle it correctly to maintain the safety and quality of suya for consumers. According to Ribah et al. (2020) the role of packaging in the food industry, which includes protection, containments, transportation, preservation and advertisement are not achieved in almost all the packaging materials and methods used by street food vendors in Nigeria.

Conclusion

The microbial quality and storage stability of chicken suya were affected by the natural antioxidant and packaging materials used. Ethiopian pepper showed considerable antimicrobial potential, particularly against total Bacillus and yeast counts when combined with foil packaging. These findings suggest that the application of selected natural antioxidants, especially Ethiopian pepper, together with appropriate packaging materials, can contribute to maintaining the microbial quality and improving the storage stability of chicken suya.

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