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Evaluation of the shelf life and quality of kilishi prepared with different slurries

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ABSTRACT: The shelf life and quality of kilishi prepared with different slurries were evaluated. Fresh beef was purchased from the market, sliced into thin sheets and sun-dried. Thereafter, the groundnut, bambaranut and soybean slurries were prepared with the addition of spices and seasonings. Afterwards, the dried beef samples were weighed and divided equally into three groups. The first group was infused into the groundnut slurry, the second group was infused into the bambaranut slurry and the third group was infused into the soybean slurry and sundried. The dried infused beef slices were roasted, cooled, packaged in an air-tight container and stored for 16 weeks at an ambient temperature of 28±2ºC for proximate, microbial, thiobarbituric acid and sensory analysis. The proximate analysis showed a significant difference ($p<0.05$) in fat, ash and nitrogen free extract while no significant difference ($p>0.05$) was found in moisture, crude protein and fibre content across the samples. Kilishi made with groundnut slurry had the highest fat content (17.46%) whereas the highest ash content (5.37 %) and nitrogen free extract were observed in kilishi made with bambaranut slurry respectively. No significant difference ($p<0.05$) was observed in thiobarbituric acid and microbial counts except on the *Salmonella* with the highest count ($1.39x10^3$ CFU/g) found in kilishi made with groundnut slurry while the lowest count ($1.18x10^3$ CFU/g) was found in kilishi made with soybean slurry. Similarly, no significant difference ($p>0.05$) was found in sensory parameters except in overall acceptability. Kilishi made with groundnut slurry was most accepted with a score of 7.50. The findings suggest that bambaranut and soybean slurries can serve as viable alternatives in kilishi production, offering nutritional and microbial stability comparable to groundnut-based kilishi.

Keywords: Proximate composition, microbial counts, bambaranut, soybean.

INTRODUCTION

Kilishi is a sundried meat. It is a meat snack product usually sold by hawkers in streets, roadside, bus stops, marketplaces and other areas of business attraction (Okwori *et al*., 2009). It is an important part of Nigerian food culture, and its production and consumption have economic and social significance (Iheagwara and Okonkwo, 2016). Kilishi is a rich source of protein, fat, minerals and vitamins (Adeyeye, 2016). It is made from thinly sliced fresh lean strips or slices of muscle which are dipped into a slurry made of defatted groundnut paste and spices and sundried (Ogunsola and Omojola, 2008). It can be prepared from beef, mutton, chevon and other types of meat. However, beef is mostly used (Abubakar *et al*., 2011). According to Kibon (2006), kilishi is mainly produced by traditional producers and it is concentrated in northern Nigeria, where there is abundant livestock production and sunshine. It is moderately acidic and has low moisture content which aids its stable shelf life by limiting the growth of harmful microorganisms, and improved storage conditions (Abubakar *et al*., 2011). Slurry ingredients used in kilishi production are composed of a medley of spices, herbs, and other seasonings which not only impart complex flavours but also serve as tenderizers to the meat, ensuring a succulent texture upon drying (Iyiola and Bulus, 2024). The slurry has high levels of triglycerides, phospholipids and polyunsaturated fatty acids and subsequently high amounts of malonaldehyde (Mediani *et al*., 2022) that aid its preservation. Kilishi has a long shelf life which is attributed to the dehydration process that reduces the moisture content which in turn

hinders the growth of microorganisms and spoilage (Yusuf *et al*., 2020).

The period of storage is a critical factor in the shelf life of kilishi as it can affect the quality of *Kilishi* and lead to changes in nutritional composition, sensory quality and microbial load (Iyiola *et al*., 2023; Iyiola and Aladi, 2023). Previous studies have shown that kilishi can be stored for one year without significant changes in quality (Igene *et al*., 1988). According to Chukwu and Imodiboh (2009), significant changes occurred during the period of storage while Iheagwara *et al*. (2019) reported variability in the microbial stability of kilishi with certain processing methods yielding better microbiological profile. However, Iyiola *et al*. (2023) reported a significant effect of the period of storage on the quality of kilishi. Despite the increase in acceptance and consumption of kilishi, it is increasingly being criticized in recent times due to the unhygienic conditions involved in its production, inadequate processing methods and microbiological stability as they directly influence the product safety for consumption (Ada *et al*., 2022). Thus, Ogunsola and Omojola (2007) reported the highest microbial load on foil-packaged kilishi and the presence of *Bacillus spp*., *Staphylococcus spp*. and *Proteus spp*. on kilishi made from pork and beef which could pose a public health risk. Igene *et al*. (2016) reported the microbiological safety of kilishi after 6 months of storage, however, minimal counts of *Bacillus cereus*, *Staphylococcus aureus*, *Streptococcus sp*, and *Fungi* were observed on the stored kilishi. In this regard, there is a scientific gap and little literature on the shelf life of kilishi produced with different slurries. It is therefore necessary to evaluate the shelf life of kilishi made with different slurries. The study will aid in bridging the knowledge gap, provide useful data and information for kilishi producers, meat processors, and consumers and public health personnel for evaluation purposes. Hence, the objective of this study is to evaluate the shelf life and quality of kilishi prepared with different slurries.

MATERIALS AND METHODS

Study area and sources of experimental materials

The research was carried out at the Laboratory of Soil Science of the Faculty of Agriculture and Life Sciences, Federal University Wukari, Nigeria. Fresh beef meat, ingredients (soybean, bambaranut, groundnut, seasonings and spices) and other equipment used in the study were purchased at the old market in Wukari Metropolis.

Meat preparation

This was carried out according to the method described by Alamuoye (2019) with little modification. 6 kg of beef from the round of freshly slaughtered carcass was trimmed free of fat, bones and excess connective tissues. The chunk was cut into smaller portions within the size of 150-200g. Thereafter each portion was sliced along the fibre axis into thin slices of about 2 mm thickness in continuous sheets. The pieces of sliced meat were then spread on the wooden mat and sun-dried during the day on an elevated platform to avoid microbial contamination. This first stage of drying lasted for about 7-8 hours depending on the relative humidity, intensity of the sun and air velocity. The meat stripes were turned over every hour to allow them to dry properly and prevent them from getting stuck to the drying surfaces. The dried meat was kept in airtight containers for further processing.

Slurry preparation

This was done according to the method described by Iyiola *et al*. (2021) with little modification. The major ingredient in processing kilishi is the defatted groundnut paste. The defatted groundnut paste was obtained from the dehulled seed and roasted for 10-15 minutes and cooled. The testa was removed, cleaned, and milled into paste with grinding machine. The milled paste was put in a bowl on a table and kneaded, and the oil was extracted as the kneading proceeded. The defatted groundnut paste obtained after the extraction was used in slurry preparation. The same method was used in the preparation of bambaranut and soybean paste except warm water was added to bambaranut and soybean paste to allow easy extraction of their oils. This was prepared on the day of production to avoid rancidity. To the resultant pastes from defatted groundnut, bambaranut and soybean respectively, the blended spices and seasonings were added as shown in Table 1. The different mixtures were mixed with 36 mL of clean water using a mortar and pestle until a uniform paste was formed. The slurries were produced on the day of kilishi production to prevent microbial spoilage and minimized the possible development of rancid flavour.

Kilishi preparation

This was done according to the procedure described by Iyiola *et al*. (2021). The dried beef samples of the same batch were weighed and divided equally into three treatment groups (1, 2 and 3). The first group of dried beef was infused into the groundnut slurry (Treatment 1) which serves as the control. The second group was infused into bambaranut slurry (Treatment 2) while the third group was infused into soybean slurry (Treatment 3). Each of the treatments was done one after the other and replicated thrice. They were left for 1 hour in other to allow the slurries to penetrate the sliced beef. After which they were carefully spread out on the wooden mat and sundried between 10 - 12 hours. The infused beef slices were then roasted for 5 – 10 minutes to enable the ingredients in the products to

Table 1. Ingredient composition of the slurries.

Ingredients	Groundnut slurry (g)	Bambaranut slurry (g)	Soybean slurry (g)
Groundnut	36.00	0.00	0.00
Soybeans	0.00	0.00	36.00
Bambaranut	0.00	36.00	0.00
Ginger	3.00	3.00	3.00
Garlic	1.00	1.00	1.00
Black pepper	2.00	2.00	2.00
Red pepper	2.00	2.00	2.00
Sweet pepper	2.00	2.00	2.00
Alligator pepper	1.00	1.00	1.00
Onion	5.00	5.00	5.00
African nut meg	2.00	2.00	2.00
Curry	2.00	2.00	2.00
Salt	3.00	3.00	3.00
Knorr ©	2.00	2.00	2.00
Sugar	3.00	3.00	3.00
Water (mL)	36.00	36.00	36.00
Total	100	100	100

fasten to it and destroy any microorganisms that might have contaminated the meat samples during sun drying. The samples were judged sufficiently dry when they became crispy to the touch and brown. Thereafter, they were cooled on a tray and then packaged in different air-tight plastic containers and stored for 16 weeks on a shelf at an ambient temperature of 28±2ºC for proximate, microbial, thiobarbituric acid analysis and sensory analysis.

Proximate analysis of kilishi

At the end of 16 weeks of storage, the kilishi samples were taken to the laboratory for proximate analysis which was done according to the methods described by AOAC (2006) to determine moisture content, crude protein, total ash, crude fat and crude fibre. Moisture content was determined by drying 5 g of kilishi sample in an oven at a temperature of 105°C to a constant weight. The crude protein of the kilishi samples was determined by Kjeldahl methods while fat was obtained by Soxhlet extraction method using petroleum ether. The ash content of kilishi was obtained by igniting 1 g of kilishi sample in a Muffle furnace at 500°C for 5 - 6 hours until ashes were produced.

Microbial analysis

This was done at the end of 16 weeks of storage according to the procedure described by Buhari *et al*. (2012). Using a sterile knife, 10 g of the sample was cut and transferred aseptically into 90 mL of 0.1% sterile peptone water (Soak solution). It was allowed to sock for about 10 minutes after which 1 ml was transferred into a bottle containing 0.1% sterile peptone water (10^{-1}) dilution. This was severally diluted with 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 fungi colonies grown on both media were counted and the result was expressed as colony forming unit per gram (CFU/g) by using the formula:

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

Thiobarbituric acid analysis

Thiobarbutric acid value was determined according to the procedure described by Zeb (2012). 1 g of a well-blended sample was weighed into a test tube and 5 ml of solvent (glacial acetic acid) was added, shaken for 1 hour and centrifuged. 1 mL of each standard Malondialdehyde tetrabutylammonium salt (MDA salt) concentration was pipetted into a test tube and 1 mL of TBA solution was added. 1 mL of the filtrate from the sample was also pipetted into a test tube and 1 mL of TBA solution was added. The contents of the test tubes (all standard test tubes and sample test tubes) were heated at 95°C in a

boiling water bath for 60 minutes. The test tubes were removed and allowed to cool at room temperature. The absorbance of both the samples and standards at a wavelength of 532 m was read and the blank was prepared by replacing the solvent or sample with glacial acetic acid. All other protocols were duly observed for the blank and a calibration curve was constructed for the standards of absorbance versus concentration. From the calibration curve, the absorbencies of the sample were extrapolated down to the concentration axis of the standard graph to obtain the concentration of the sample in Um. Thiobarbituric acid was calculated thus:

$$\text{mg/g TBA} = \frac{\text{mg/ml (from graph) x Volume of Extract}}{\text{Sample weight}} \text{ x Dilution Factor}$$

Sensory analysis of kilishi

Sensory analysis was conducted at the end of the 16-week storage period according to the method described by Nasiru *et al*. (2011). Ten samples of kilishi from each slurry treatment were served randomly to 15 staff panelists drawn from the Department of Animal Production and Health of the Faculty of Agriculture and Life Sciences, Federal University Wukari, Nigeria. Panel membership was voluntary, and panelists were selected based on their interests and ability to understand the test procedures. Each staff evaluated two kilishi samples and each of the samples was given one at a time and evaluated using the sensory questionnaires. The samples of the kilishi were evaluated for overall appearance, colour, tenderness, juiciness, flavour and overall acceptability characteristics using a 9-point hedonic rating scale as described by Ranganna (2001) on which 1=dislike extremely and 9=like extremely.

Statistical analysis

The data generated were statistically analyzed using one–way analysis of variance (ANOVA) and the differences in means were separated using Least Significant Difference (LSD). The Statistical package SPSS 20 Version was used for this analysis.

RESULTS AND DISCUSSION

Proximate composition

The proximate composition of kilishi made with different slurries presented in Table 2 showed a significant difference ($p<0.05$) in fat, ash and nitrogen free extract contents in the kilishi samples while no significant difference ($p>0.05$) was found in moisture, crude protein and fibre contents across the *Kilishi* samples. However, low moisture content was observed across the kilishi samples with kilishi made with bambaranut being a little higher in moisture content (10.37%) than other samples. Moisture is a critical factor that influences the shelf life of a product (Yunusa *et al*., 2023). Therefore, the low moisture content found across the kilishi samples after 16 weeks of storage aid in extending the shelf life of kilishi making it a valued protein source in regions with limited power supply and refrigeration (Aworh, 2023). The low moisture content is attributed to two steps of drying that was used during production (Okorie, 2018, Iyiola *et al*., 2023; Chukwu and Imodiboh, 2009). It showed that the kilishi samples were properly dried to hinder microbial growth and spoilage during storage. This agrees with Chukwu and Imodiboh (2009) who reported that drying reduces the moisture content of lean meat to about 20% and the growth of most bacteria, yeasts and moulds while 15% moisture content hinders only some species of *fungi*. The range of moisture content found in this study is higher than 5.85-7.21% reported by Alamuoye (2019), 5.19-7.52% reported by Olusola *et al*. (2017), 5.43-8.05% reported by Iyiola and Bulus (2024) but similar to 10.33% reported by Okorie (2018). However, it is lower than the 10.03-12.02% reported by Iheagwara and Okonkwo (2016).

High crude protein content was observed across the *Kilishi* samples with a range value of 42.97-46.78%. Variations in crude protein content though not significantly difference ($p>0.05$) were found with kilishi made with soybean slurry having the highest crude protein content (46.78%) while the lowest crude protein was found in kilishi made with bambaranut slurry (42.97%). Protein content influences the nutritional value and texture of kilishi (Madu *et al*., 2020). Therefore, monitoring protein levels ensures consistency in product quality and nutritional composition. The high protein content observed across the samples after 16 weeks of storage is an indication that the protein content of kilishi samples was not negatively affected during storage (Iyiola *et al*., 2023). The highest protein content found in kilishi made with soybean slurry could be attributed to the preservative quality of the sample during storage which could enhance its nutritional quality and also due to the chemical composition of the slurry. This agrees with the report of Iyiola and Bulus (2024) that different chemical composition of slurries affects the proximate composition of kilishi. In addition, Iheagwara and Okonkwo (2016) reported that the high protein content found in kilishi is a result of groundnut paste used during production. Therefore, soybean slurry can be used to achieve similar result with groundnut slurry as regard to crude protein content (Iyiola and Bulus 2024, Iyola *et al*. 2021). Kilishi is a good source of protein (Adeyeye *et al*., 2020) and can be used in areas where there is scarcity of animal products. The range of crude protein in this study is higher than 30.64% reported by Okorie (2018) but lower than the range of 48.19 - 51.80% reported by Olusola *et al*. (2017), 61.30 - 61.72% reported by Iheagwara and Okonkwo (2016), 61.95% reported by Ogbonnaya and Imodiboh (2009), 66.91- 68.83% reported by Iyiola *et al*. (2021) and 48.57-50.71% reported by Iyiola and Bulus (2024).

In addition, the fat content of this study ranged from 5.27

Table 2. Proximate composition of kilishi made with different slurries at 16 weeks of storage.

Parameter	Kilishi made with groundnut slurry (%)	Kilishi made with soybean slurry (%)	Kilishi made with bambaranut slurry (%)	SEM	P-Value
Moisture content	9.54	10.07	10.37	0.39	0.39
Crude protein	43.69	46.78	42.97	2.88	0.63
Fat	17.46	10.38	5.27	1.11	0.00
Crude fibre	2.23	2.57	3.00	0.26	0.19
Ash content	4.53^{b}	5.16^{ab}	5.37^{a}	0.24	0.02
Nitrogen free extract	22.54^{b}	25.04^{ab}	33.01^{b}	2.78	0.05

^{abc} Means in the same row with different superscripts are significantly difference ($p<0.05$). SEM: Standard Error of Mean.

– 17.46%. Kilishi made with groundnut slurry was significantly ($p<0.05$) higher in fat content (17.46%) followed by kilishi made with soybean slurry (10.38%) while the lowest fat content (5.27%) was found in kilishi made with bambaranut slurry. Fat is used to determine energy value of food product and contribute to the flavour, texture and mouth feel of food (Dabasso, 2020). The highest fat content found in kilishi made with groundnut slurry could be attributed to the ability of the slurry to prevent oxidation of the fat content during storage and also due to the chemical composition of the slurry which is higher in fat compared to other slurries (Iyiola and Bulus, 2024). However, the drastic reduction of fat contents of kilishi made with bambaranut and soybean slurries after storage could be attributed to fat oxidation during storage which could be enhanced by the slurries and lead to slight loss of flavour. This agrees with the report of Aworh (2023), Iyiola *et al.* (2023) and Yusuf *et al*. (2020). Furthermore, an increase in fat contents of kilishi made with groundnut slurry after storage is an indication that the product has the capacity to maintain its fat content after storage compared to other treatment groups which could aid in the enhancement of its flavour and juiciness (Dabasso, 2020; Resconi *et al*., 2013). More so, kilishi made with soybean and bambaranut slurries could be of benefit to consumers who prefer food with lower fat content (Youl *et al*., 2012). The range of fat content in this study is higher than 3.26-4.15% reported by Yusuf *et al*. (2020), 4.75-8.29% reported by Iyiola and Aladi (2023), but lower than 22.33% reported by Okorie (2018) on freshly prepared kilishi, 17.09-22.53% reported by Olusola *et al*. (2017), 10.11 – 10.57% reported by Iheagwara *et al*. (2019), 13.33-14.24% reported by Ogunsola and Omojola (2008) on meat types kilishi and 24.28% reported by Chukwu and Imodiboh (2009).

Furthermore, a significant difference ($p<0.05$) was found in ash content across the samples. The highest ash content (5.37%) was found in kilishi made with bambaranut slurry which was not significantly different ($p>0.05$) from 5.16 and 4.53% of kilishi made with soybean and groundnut slurries respectively. The ash content of processed food was reported to be the ash content of the muscle meat with that of ingredients (Elizabeth, 1995). The ash content found on kilishi made with bambaranut and soybean slurries which were higher than that made with groundnut slurry could be attributed to the ability of the slurries used in the production to hinder loss of minerals during storage and also as a result of the chemical composition of the slurries (Iyiola and Bulus, 2024). This agrees with the report of Olusola *et al*. (2017), which stated that the ash content of kilishi is influenced by the mineral levels of the spices used in the slurry formulation, as well as the ash content of the meat sample. This implies that good mineral contents could be achieved from a stored kilishi made with bambaranut and soybean slurries. The range of ash contents in this study was similar to the range value of 4.61-5.06% reported by Iyiola *et al*. (2021) and 5.71% reported by Chukwu and Imodiboh (2009) but lower than 5.55 - 7.80% reported by Olusola *et al*. (2017), 5.88 - 7.66% reported by Igwe *et al*. (2015) and 8.74 - 10.12% reported by Alamuoye (2019).

Additionally, low crude fibre content that did not significantly ($p>0.05$) differ across the samples was found. However, kilishi made with bambaranut slurry was significantly ($p<0.05$) higher in nitrogen free extract (33.01%) than kilishi made with soybean slurry (25.04%) and kilishi made with groundnut slurry (22.54%). Meat has little or no fibre therefore the low crude fibre observed across the kilishi samples is an indication of the ingredients used in the production of slurries since they are of plant origin. This agrees with the report of Iheagwara *et al.* (2019), Iyiola and Bulus (2024) and Olusola *et al*. (2017). Similarly, the high nitrogen free extract observed across the kilishi samples is from the ingredients used since they are of plant origin (Olusola *et al.,* 2012; Iyiola *et al.,* 2023). The highest nitrogen free extract observed in kilishi made with bambaranut slurry after 16 weeks of storage could be attributed to the chemical composition of the slurry (Iyiola and Aladi, 2023). This is an indication that kilishi produced with bambaranut slurry could maintain its nitrogen free extract content after storage compared to other treatment groups. The range value of nitrogen free extract in this study is higher than the range of 12.78 -31.72% reported by Iyiola *et al*. (2023) and 22.68 - 22.88% reported by Iyiola and Bulus (2024).

Microbial counts

The microbial counts of kilishi made with different slurries

Table 3. Microbial counts and thiobarbituric acid value of kilishi made with different slurries at 16 weeks of storage.

Parameter	Kilishi made with groundnut slurry (CFU/g)	Kilishi made with soybean slurry (CFU/g)	Kilishi made with bambaranut slurry (CFU/g)	SEM	P-Value
TVBC	$2.95x10^3$	$2.91 x10^3$	$2.55 x10^3$	$4.98 x10^2$	0.63
E. coli	$0.88 x10^2$	$0.78 x10^2$	$0.79 x10^2$	3.18	0.30
Coliform	$0.16 x10^2$	$0.16 x10^2$	$0.18 x10^2$	0.67	0.79
Fungi	$0.34 x10^2$	$0.28 x10^2$	$0.26 x10^2$	2.08	0.07
Salmonella	$1.39 x10^{3a}$	$1.18 x10^{3c}$	$1.29 x10^{3b}$	1.53	0.00
Staphylococcus	$0.81 x10^2$	$0.71 x10^2$	$0.92 x10^3$	9.54	0.59
Thiobarbituric Acid value (mg MDA/kg)	0.20	0.18	0.19	0.69	0.14

[abc] Means in the same row with different superscripts are significantly difference ($p<0.05$). SEM: Standard Error of Mean. TVBC: Total Viable Bacteria Count.

at 16 weeks of storage presented in Table 3 showed no significant difference ($p>0.05$) in most of the microbes evaluated except in *Salmonella* where a significant difference ($p<0.05$) was observed across the kilishi samples. Microbes such as *Escherichia coli*, Coliform, *Fungi*, *Salmonella* and *Staphylococcus* were isolated from the kilishi samples. However, low microbial counts were found across the treatment groups after 16 weeks of storage and the total viable bacterial counts of this study ranged from 2.55×10^3 - 2.95×10^3 CFU/g. The highest count (2.95×10^3, 0.88×10^2, 0.34×10^2 and 1.39×10^3 CFU/g) of total viable bacteria, *E. coli, fungi and Salmonella* were found in kilishi made with groundnut slurry while the lowest count (0.78×10^2, 1.18×10^3 and 0.71×10^2 CFU/g) of *E. coli*, *Salmonella* and *Staphylococcus* were found in kilishi made with soybean slurry respectively.

Microbial quality and safety of meat products are very important in ensuring consumer health and food security (Shamsuddeen, 2009). It also determines the shelf life of a product (Ada *et al*., 2022). The low microbial counts observed across the kilishi samples after storage could be attributed to the low moisture content found on the samples (Table 2) which aid in their preservation by retarding the multiplication of the microbes and extending their shelf life. In addition, it could also be due to the storage condition (ambient temperature) and impacts of the spices used. Spices have been reported to play a role in the microbiological quality of a product by inhibiting the growth and multiplication of microorganisms through its antimicrobial and antioxidant activity (Munekata, 2021; Brandi *et al*., 2006, Jackson *et al*., 2002; Botsoglou *et al*., 2003). The presence of isolated microbes in the kilishi samples after storage in this study is in agreement with the report of Igene *et al*. (2016) who isolated *Fungi*, *Staphylococcus*, *E. coli* and *Salmonella* at different stages of storage of kilishi. Iheagwara and Okonkwo (2016) also isolated *Staphylococcus*, *Fungi* and Coliform on the study of the effect of processing methods on the microbial quality of kilishi. *E. coli*, *Salmonella spp*., *Staphylococcus aureus*, *Staphylococcus epidermidis and Fungi* were also isolated from kilishi sold in Nasarawa as reported by Ada *et al*. (2022). The presence of microbes could be attributed to the contamination during production from utensils, equipment and handling of the samples (Abdullahi *et al*., 2005; Iyiola *et al*., 2021; Iyiola and Bulus, 2004). Similarly, the high counts of *Salmonella* found could be through the handling of the products during production (Jay, 2000). However, the highest bacterial counts found on kilishi made with groundnut slurry are contrary to the report of Iyiola and Bulus (2004) who reported the highest bacterial counts ($1.37 – 3.03 \times 10^7$ CFU/g) in kilishi made with soybean slurry after production. This implies that the shelf life of kilishi produced with groundnut slurry could be altered or reduced during storage due to the presence of greater number of microbes compared to other treatment groups. The range value of all the microbial counts observed in this study is within the recommended range of less than 10^6 cfu/g as satisfactory limit, and 10^6 to $<10^7$ cfu/g as acceptable range (London Health Protection Agency, 2009) and a range limit between 2.5×10^5 to 1.0×10^8 CFU/g for consumable meat products (ICMSF, 1996). Therefore, the result indicated that kilishi samples at 16 weeks of storage are fit for consumption and do not pose any health risk to the public. The range of values for *Staphylococcus*, Coliform and *Fungi* counts in this study are low compared to the range of values (3.0×10^4-7.0×10^4, 1.04×10^4 - 3.0×10^4 and 2.4×10^4 - 5.9×10^4 CFU/g) of *Staphylococcus*, Coliform and *Fungi* counts reported by Olusola *et al*. (2017) respectively, 2.02×10^4 - 3.08×10^5 and 1.55×10^5 - 8.55×10^5 (CFU/g) of *Staphylococcus* and *Fungi* counts respectively reported by Iheagwara and Okonkwo (2016) on kilishi at100 days of storage. However, the Total Viable Bacteria counts (TVBC) in this study are lower compared to the range value of 4.07×10^4 - 4.67×10^4 and 3.71×10^4 - 4.28×10^4 (CFU/g) reported by Iyiola *et al.* (2021, *2023)* on oven-dried kilishi made with different slurries and meat types respectively.

Thiobarbituric acid value

Thiobarbituric acid value of kilishi made with different

Table 4. Sensory score of kilishi made with different slurries at 16 weeks of storage.

Parameters	Kilishi made with groundnut slurry	Kilishi made with soybean slurry	Kilishi made with bambaranut slurry	SEM	P-Value
Overall Appearance	7.90	6.60	6.20	0.67	0.16
Colour	6.70	6.20	6.50	0.59	0.83
Flavour	6.80	5.90	6.90	0.57	0.41
Tenderness	5.80	5.70	6.40	0.62	0.69
Juiciness	6.50	5.60	6.00	0.71	0.67
Overall acceptability	7.50[a]	5.70[b]	7.20[a]	0.43	0.02

[abc] Means in the same row with different superscripts are significantly difference ($p<0.05$), SEM: Standard Error of Mean.

slurries at 16 weeks of storage presented in Table 3 showed no significant difference ($p<0.05$) across the kilishi samples. A low value that ranged from 0.17 to 0.20 mgMDA/kg was found on thiobarbituric acid of the kilishi across the samples. Thiobarbituric acid value is used to assess the malnonaldehyde which results from lipid peroxidation of polyunsaturated fatty acids. The low thiobarbituric acid value observed across the kilishi samples after 16 weeks of storage could be attributed to the spices used since they contain antioxidant properties that hinder lipid oxidation (Brandi *et al*., 2006; Lagouri and Nisteropoulou, 2009). This is in agreement of Kharb and Ahiawat (2010) who reported that spices significantly reduced the thiobarbituric acid value (TBA) in pre-cooked dehydrated meat products. Alamuoye (2019) also reported that garlic powder as an additive of up to 8% delayed lipid oxidation in kilishi. The low thiobarbituric value in this study is an indication that the kilishi samples are safe for consumption and do not pose any public health risk since they fall within the recommended range of 1-2 mgMDA/kg (Iheagwara *et al*., 2019). The thiobarbituric acid range value in this study is lower than the range of 0.1 - 0.6 mgMDA/kg reported by Alamuoye (2019) and 1.49 - 1.68 mgMDA/kg reported by Iheagwara *et al*. (2019).

Sensory quality

The sensory quality of kilishi made with different slurries presented in Table 4 showed no significant difference ($p>0.05$) in all the sensory parameters across the treatments except in overall acceptability where significant difference ($p<0.05$) was found. Kilishi made with groundnut slurry had the highest overall acceptability score (7.50) which was similar to kilishi made with bambaranut slurry (7.20) but significantly ($p<0.05$) differs from kilishi made with soybean slurry (5.70). Although significant difference ($p<0.05$) was not observed in other parameters, however, the scores varied numerically. Kilishi made with groundnut slurry had the highest sensory scores of 7.90 and 6.70 in overall appearance and colour respectively. Whereas kilishi made with bambaranut slurry had the highest sensory scores of 6.90 and 6.40 in flavour and tenderness across the samples respectively.

Sensory evaluation is a scientific method that measures and analyzes how people perceive the product sensory characteristics through sight, smell, taste, and hearing (Eskandari *et al*, 2013). According to Mihafu *et al*. (2020), it can be used for product development, quality control, shelf life testing, market research and consumer evaluation. The no significant differences ($p<0.5$) observed in the sensory parameters is an indication that the kilishi made with bambaranut and soybean slurries had similar sensory qualities to that made with groundnut slurry. In addition, the result showed that at 16 weeks of storage, the sensory qualities of the kilishi samples were good and not negatively affected by microorganisms and lipid oxidation during storage because of the low thiobarbituric acid value and microbial counts obtained in this study (Table 3). This contradicted the reports of Yusuf *et al*. (2020) that 3 to 6 months of storage affects the colour and visual appeal of a dried product due to oxidation and Faustman *et al*. (2010) reported that lipid oxidation causes the fatty acids to be broken down into smaller molecules that negatively affect flavour and odour and this can also quicken the discolouration which is believed to take place through reaction with myoglobin. Furthermore, Faustman *et al*. (2010) reported that the appearance of meat specifically is an important factor in how consumers perceive the quality of meat. Several authors have also reported that fat is a precursor of the flavour and juiciness of a product (Dabasso, 2020; Resconi *et al*., 2013; Iyiola and Bulus, 2024). Therefore, the highest overall acceptability score found in kilishi made with groundnut slurry after storage could be attributed to its colour and overall appearance because of its highest score in both parameters across the kilishi samples. Consequently, the flavour and juiciness score found in kilishi made with groundnut slurry could be attributed to its high-fat contents after storage (Table 2). Hence. kilishi made with groundnut slurry was highly accepted and preferred by the panelists compared to other kilishi samples which could aid in its marketability. The highest tenderness and flavour score found in kilishi made with bambaranut slurry showed that kilishi made with bambaranut was more flavoured and tenderer after storage compared to other treatment groups. While the low sensory parameters found in kilishi made with soybean slurry imply that after storage the kilishi

samples were less preferred and accepted by the panelists compared to other treatment groups. The results are similar to the report of Iyiola and Bulus (2024) which could be attributed to the slurries used. This is in agreement with the report of Alamuoye *et al*. (2024) that slurries aid in enhancing the overall sensory qualities of kilishi by adding value to its unique flavour profile, tenderness, and preservation qualities. The range of flavour, colour and juiciness in this study is higher than 6.7±1.34, 5.4±1.50 and 4.4±1.71 of flavour, colour and juiciness of kilishi made from beef respectively as reported by Iheagwara *et al*. (2019) while the range of flavour in this study is similar to 6.20 - 6.80 of flavour but higher than 2.80-3.60 of tenderness of kilishi reported by Alamuoye (2019).

Conclusion

In the evaluation of the shelf life of kilishi made with different slurries (groundnut, bambaranut, soybean), significant differences ($p<0.05$) were found in fat, ash and nitrogen free extract while no significant differences ($p>0.05$) were found in moisture, crude protein and fibre contents across the kilishi samples. Kilishi made with groundnut slurry had the highest fat content (17.46%) followed by kilishi made with soybean slurry (10.38%) whereas the highest ash (5.37%) and nitrogen free extract (33.11%) were found in kilishi made with bambaranut slurry. In addition, no significant differences ($p>0.05$) were found in thiobarbituric acid value and microbial counts across the kilishi samples except on *Salmonella* where a significant difference ($p<0.05$) was observed in kilishi made with groundnut slurry having the highest count ($1.39x10^3$ CFU/g) across the samples. Microbes such as *Staphylococcus*, *Salmonella*, *E. coli*, *Fungi* and *Coliform* were isolated from the kilishi samples However, the microbial counts found across the kilishi samples are within the recommended acceptable range limit between 2.5×10^5 to 1.0×10^8 CFU/g which is an indication that the kilishi samples are safe for consumption and do not pose public health risk. Similarly, no significant difference ($p>0.05$) was found in the sensory score parameters evaluated except on overall acceptability where kilishi made with groundnut slurry was significantly ($p<0.05$) higher (7.50) than other samples. Therefore, bambaranut and soybean slurries should be used in the production of kilishi since they have similar sensory qualities, good shelf life after storage with an indication of lower microbial counts and better nutritional quality especially in crude protein, ash, crude fibre and nitrogen free extract contents than that made with groundnut slurry.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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REFERENCES

Abdullahi, I. O., Umoh, V. J., Ameh, J.B., & Galadima, M. (2005). Comparative assessment of the microbiological quality of three local meat products as sold in Zaria, Nigeria. *Nigeria Journal of Scientific Research*, *5*(1), 56-60.

Abubakar, M. M., Bube, M. M., Adegbola, T. A., & Oyawoye, E. O. (2011). Assessment of four meat products (Kilishi, Tsire, Dambu and Balangu) in Bauchi Metropolis. *ACT-Biotechnology Research Communications*, *1*(1), 40-48.

Ada, A.I., Isa, S., & Ada, A.O. (2022) Microbiological quality of kilishi sold in Nasarawa, Nasarawa State. *Journal of Food Microbiology, Safety and Hygiene*, 7, 068

Adeyeye, E. I., Oseni, O. A. A., Popoola, K. O., Gbolagade, Y. A., Olatoye, A. R., & Idowu, K. (2020). Amino acid composition of kilishi-Nigerian (beef jerky) meat. *Sustainable Food Production*, 8, 1-16.

Adeyeye, S. A. O. (2016). Safety issues in traditional West African foods: A critical review. *Journal of Culinary Science & Technology*, *15*(2), 101-125.

Alamuoye, N. O., Alamuoye, O. F., & Adebayo, F. B. (2024). Moisture sorption isotherm, proximate composition, lipid oxidative stability and sensory characteristics of sun dried kilishi in storage. *Asian Journal of Food Research and Nutrition*, *3*(2), 320-328.

Alamuoye, O. F. (2019). Effect of dietary garlic powder as additive on quality of kilishi: A dried meat produced from West African dwarf ram. *International Journal of Food Science and Nutrition*, *5*, 18-22.

AOAC (2006). Association of Official Analytical Chemists. Official Methods of Analysis. In: Horwitz, W. (ed.), 18th Edition. AOAC Press, Arlington, VA, USA. Pp. 1-48.

Aworh, O. C. (2023). African traditional foods and sustainable food security. *Food Control*, *145*, 109393.

Botsoglou, N. A., Grigoropoulou, S. H., Botsoglou, E., Govaris, A., & Papageorgiou, G. (2003). The effects of dietary oregano essential oil and α-Tocopheryl acetate on lipid oxidation in raw and cooked turkey during refrigerated storage. *Meat Science*, *65*, 1193-1200.

Brandi, G., Amagilani, G., Schiavano, G. F., De Santi, & Sisti, M. (2006). Activity of *Brassica oleracea* leaf juice on food borne pathogenic bacteria. *Journal of Food Protection*. 69, 2274 - 2279.

Buhari, A-S. M., Kamaldeen, A-S. K., & Hassan Ummu, K. M. (2012). Isolation of fungal flora in carpet and floor dust samples as an indicator of indoor air quality (IAQ): A case study of a Nigerian Institution. *International Journal of Scientific and Research Publications*, 2(8), 22-28.

Chukwu, O., & Imodiboh, L. (2009). Influence of storage conditions on shelf life of dried beef products (kilishi). *World Journal of Agricultural Sciences*, *5*(1), 34-39.

Dabasso, B. G. (2020). Traditional meat processing knowledge, social-cultural values, nutritional quality and safety amongst the Borana women of Northern Kenya. Doctoral dissertation, Food Science and Nutrition, Jomo Kenyatta University of Agriculture and Technology Kenya.

Elizabeth, B. (1995). Ingredients in processed meat products paper presentation. Department of Animal Science and

Industry Kansas State University, USA. Pp. 01-09.
Eskandari, M. H., Majlesi, M., Gheisari, H. R., Farahnaky, A., & Khaksar, Z. (2013). Comparison of some physicochemical properties and toughness of camel meat and beef. *Journal of Applied Animal Research*, *41*(4), 442-447.
Faustman, C., Sun, Q., Mancini, R., & Suman, S.P. (2010). Myoglobin and lipid oxidation interactions: mechanistic bases and control. *Meat Science*, *86*, 86-94.
Igene, J. O. (1988). Lipid, fatty acid composition and storage stability of kilishi, a sun-dried meat product. *Tropical Science*, *28*(3), 153-161.
Igene, J. O. (2008). *Traditional African meat products for food security and agroindustrialization: Development challenges*. Lambert Academic Publishing, Germany, Pp. 1-210.
Igene, J. O., Uwadia, O. E., Ebabhamiegbebho, P. A., & Evivie, S. E. (2016). Shelf life stability studies of University of Benin (Uniben) proff's kilishi product. *Asian Journal of Science and Technology*, *7*, 2268-2274
Igwe, E. J., Abdulahi, N., Abusalam, N., Dandago, M. A., & Obiegbuna, E. J. (2015). Evaluation of production techniques and quality assessment of Kilinshi in some parts of Kano State, Nigeria. International *Journal of Basic Science and Technology*, *1*(1), 35-38.
Iheagwara, M. C., & Okonkwo, T. M. (2016). Physicochemical and organoleptic characteristics of kilishi as affected by storage duration and ingredient formulation. *Journal of Food Research and Technology*, *4*(1), 1-9.
Iheagwara, M. C., Chibuzo, I. H., Ibeabuchi, J. C., & Nzuruike, N.G. (2019). Physicochemical and organoleptic characteristics of kilishi as affected by meat types. *Annals Food Science and Technology*, *20*, 553-562.
International Commission on Microbiological Specifications for Food (ICMSF) (1996). Microorganisms in foods 5: Microbiological specifications of pathogens. p. 89
Iyiola, V. O., & Aladi, N. O. (2023). effects of processing methods on quality characteristics of kilishi jerkies. *FUDMA Journal of Agriculture and Agricultural Technology*, 9(4), 61-68.
Iyiola, V. O., & Bulus, S. U. (2024). Effects of slurries on the quality of kilishi. *Journal of Animal Science and Veterinary Medicine*, *9*(5), 213-221.
Iyiola, V. O., Aladi, N. O., Anyanwu, V. C., & Okeudo, N. J. (2021). Proximate composition and microbial count of oven dried kilishi-like jerkies made with different slurry types. 26th Annual Conference of Animal Science Association of Nigeria-Nigerian Institute of Animal Science (ASAN-NIAS), Uyo Nigeria.
Iyiola, V. O., Aladi, N. O., Okeudo, N. J., Achonwa, C. C., Ojinnaka, P. E., & Okoli, I. C. (2023). Proximate composition and microbial count of oven dried Kilishi like jerkies made from different meat types. *Nigerian Journal of Animal Science*, *25*(1), 193-203.
Jackson, R., McNeil, B., Taylor, C., Holl, G., Ruff, D., & Gwebu, E. T. (2002). Effect of aged garlic extract on casepase-3 activity, *in vitro*. *Nutritional Neuroscience*, *5*, 287-290.
Jay, M. J. (2000). *Modern food microbiology* (6th edition). Aspen Publishers Inc., Gaithersburg, Maryland. Pp. 60-89.
Kharb, R., & Ahlawat, S. S. (2010). Effect of precooking and spices on quality characteristics of dehydrated spent hen meat mince. *Indian Journal of Poultry Science*, *45*, 100-102.
Kibon, A. (2006). Evaluation of processing technology for animal product. *Proceedings of the 31st Annual Conference of National Society of Animal*, 12th-15th March, 2006.
Lagouri, V., & Nisteropoulou, E. (2009). Antioxidant properties of O. onites, T. vulgaris and O.basilicumspecies grown in Greece and their total phenol and rosmarinic acid content. *Journal of Food Lipids*, *16*, 484-498.
London Health Protection Agency (2009). Guidelines for assessing the microbiological safety of ready-to-eat foods. London: Health Protection Agency. p. 9.
Madu, A., Okwu, D. E., & Onuh, J.I (2020). Nutritional evaluation of kilishi. *Journal of Food Science and Nutrition*, *15*(3). 45-52
Mediani, A., Hamezah, H. S., Jam, F. A., Mahadi, N. F., Chan, S. X. Y., Rohani, E. R., & Abas, F. (2022). A comprehensive review of drying meat products and the associated effects and changes. *Frontiers in Nutrition*, *9*, 1057366.
Munekata, P. E. (2021). Improving the sensory, nutritional and physicochemical quality of fresh meat. *Foods*, *10*(9), 2060.
Nasiru, A., Muhammad, B. F., & Abdullahi, Z. (2011). Effect of cooking time and potash concentration on organoleptic properties of red and white meat. *Journal of Food Technology*, *9*(4), 119-123.
Ogunsola, O. O., & Omojola, A. B. (2008). Qualitative evaluation of Kilishi prepared from beef and pork. *African Journal of Biotechnology*, *7*(11), 1753-1758.
Okorie, P. A. (2018). Processing effect of the microbial and proximate composition of Kilinshi at South East, Nigeria. *International Journal of Research Grathaalayal*, 6(5), 340-345.
Okwori, A. E. J., Obioha, C., Olabode, A. O., Etukudoh, N. S., Lugos, M. D., Turay, A. A., Udeani, T. K. C., & Okwori, E. (2009). Bacteriology of dried meat (Kilishi) hawked in Some Northern Nigerian Cities. *Nigerian Journal of Biotechnology*, *20*, 1-6.
Olusola, O. O., Okubanjo, A. O., & Omojola, A. B. (2012). Nutritive and organoleptic characteristics of Kilishi as affected by meat type and ingredient formulation. *Journal of Animal Prodution Advances*, 2(5), 221-232
Olusola, O. O., Abunwune, R. N., & Adeshola, A. T. (2017). Quality evaluation of kilishi, an intermediate moisture meat product sold in Zaria metropolis, Nigeria. *Nigerian Journal of Animal Science*, *19*(2), 271-279.
Ranganna, S. (2001). *Handbook of analysis and quality control for fruits and vegetable products*. Tata McGraw Hill Book Co., New Delhi, India (7th Edition). Pp. 594-625.
Resconi, V. C., Escudero, A., & Campo, M. M. (2013). The development of aromas in ruminant meat. *Molecules*, *18*(6), 6748-6781.
Shamsuddeen, U. (2009). Microbiological quality of spice used in the production of Kilishi a traditionally dried and grilled meat product. *Bayero Journal of Pure and Applied Sciences*, *2*(2), 66- 69.
Youl, P., Baade, P., & Meng, X. (2012). Impact of prevention on future cancer incidence in Australia. *Cancer Forum*, 36(1).
Yunusa, S. U., Isiaka, M., & Kabir, U. (2023). Modification and performance evaluation of a charcoal-fired meat (kilishi) dryer. *Proceedings of the Nigerian Institution of Agricultural Engineers*, *43*, 1-14.
Yusuf, H. L., Igwegbe, A. O., Idakwo, P. Y., Ahmad, G., & Sani, A. (2020). Physico-chemical and microbiological analyses of a smoke-dried meat product (Kamsa) during six months storage period. *Agricultural Research & Technology: Open Access Journal*, *24*(2), 48-52.
Zeb, A. (2012). Triacylglycerols composition, oxidation and oxidation compounds in camellia oil using liquid chromatography-mass spectrometry. *Chemistry and Physics of Lipids*, *165*(5), 608-614.