**Original Research Article**

**EFFECT OF PERIOD OF STORAGE ON PROXIMATE AND SENSORY QUALITIES OF KILISHI PRODUCED WITH DIFFERENT SLURRIES**

**Abstract**

The study evaluated the effect of period of storage on proximate and microbial of kilishi produced with different slurries. Fresh beef was purchased, trimmed off of fats, sliced into thin sheet, washed and sundried. Thereafter the dried meat samples were divided equally into three groups and each of the groups was infused into different slurries prepared from defatted groundnut, soybean and Bambaranut pastes which were seasoned with a blend of spices and seasoning for one hour. After which they were sun-dried, roasted, cooled, packaged and stored for 16th weeks. The experiment was replicated thrice and thereafter, proximate and sensory analyses were carried out on the 1st and 16th weeks of storage. Data obtained were statistically analyzed using 2-way Analysis of Variance in a 2x3 Factorial Arrangements. The findings revealed significant (*P =* .05) interaction effect between the period of storage and slurry types in most of the proximate parameters except on crude protein and nitrogen free extract. Moisture increased from 1st to 16th weeks of storage with kilishi made with bambaranut having the highest moisture content (10.37%) at 16th weeks of storage. Additionally, fat content in kilishi made with Bambara nut and soybean slurries drastically reduced while kilishi made with groundnut slurry increased from 14.90 to 17.46% as the samples were stored from 1st to 16th weeks of storage. Significant (*P =* .05) interaction effect of the period of storage and slurry types was observed in overall appearance, juiciness and overall acceptability across the treatment groups. Kilishi made with groundnut slurry was overall accepted (7.60 and 7.50) at both storage periods while kilishi made with bambara nut slurry showed a significant (*P* = .05) increase (6.60 to 7.20) within the period of storage. Therefore bambaranut slurry can serve as viable alternative in kilishi production, offering nutritional and sensory stability similar to kilishi made with groundnut slurry.

**Keywords**: Kilishi; Proximate composition, Sensory quality, Microbial counts, slurries

1. **Introduction**

The increasing population, urbanization, and changing dietary preferences have led to a rising demand for meat and meat products (Hawkes *et al*., 2017). However in meeting these increasing demands the meat industry has faced numerous challenges which include limited infrastructure such as poor power supply, low productivity, and inefficient value chains. Therefore the need for improved production and processing techniques was reported by (Tarrant, 1998). Among of the numerous methods that that have been employed to improve production is drying. Drying method has been used for ages to preserve meat. It prevents microbial growth and meat spoilage by reducing the moisture content of the meat (Mediani *et al*., 2022). Additionally, drying aids in storing and transporting food by reducing the size and weight of the products and contamination of the product (Ryoba *et al*., 2013).

Kilishi is one of the native meat products that are produced by drying. (Iyiola *et al*., 2023). It is a traditional sun-dried jerky made from beef, mutton or chevon (Adeyeye, 2016). It is an enrich snack with a supplemental plant protein that is formulated using hurdle technology (Iheagwara and Okonkwo, 2016). Other meats can be used in the production of kilishi but beef is mostly used (Yunusa *et al*., 2023, Abubakar *et al*., 2011). Kilishi is made from thinly sliced fresh lean strips or slices of muscle which is dipped into slurry made of defatted groundnut paste and spices and sundried (Olusola *et al*. 2017). Kilishi production is commonly produced by traditional producers localized in the northern parts of Nigeria (Kibbon, 2006). It is a rich source of protein, fat, minerals and vitamin B (Adeyeye, 2016). It is important part of Nigerian food culture, and its production and consumption have economic and social significance (Iheagwara and Okonkwo 2016). Slurries on the other hand are mixtures of ingredients use to marinate and flavor the meat before drying, and they can vary in composition and proportion (Iyiola and Bulus, 2024). Different slurries can affect the quality and shelf life of kilishi, and the choice of slurries depend on regional traditions, personal preferences, and availability of ingredients (Iyiola *et al*, 2021;).

Furthermore, quality of kilishi can be affected by various factors such as: meat type, marination process, drying method, and period of storage (Iyioa *et al*., 2023; Iyiola and Aladi, 2023). According to Iyiola *et al*. (2023), nutritional composition, sensory quality and microbial load of kilishi can be negatively or positively affected by the period of storage. Previous studies have shown that kilishi can be stored for six months to one year without significant changes in quality (Igene *et al*., 1988; Igene *et al*., 2016). Ihegwaram *et al.* (2019) reported variability in microbial stability of kilishi with certain processing methods yielding better microbiological profile while Iyiola *et al*. (2023) reported significant changes in some of the proximate parameters analyzed while no significant effect was found in microbial load of the kilishi samples. However, the effects of period of storage on the quality of kilishi produced with different slurries have not been fully investigated.

Despite the popularity of kilishi in Nigeria, consumers concern on its nutritional and sensory quality after a period of storage has greatly increased (Iheagwara and Okonkwo, 2016). Additionally, there's little scientific knowledge on the effects of period of storage on its quality, particularly when produced with different slurries. The lack of understanding of how period of storage affects kilishi's quality poses a significant challenge to meat processors and kilishi industry. This knowledge gap may lead to inconsistent quality, reduced nutritional quality, shelf life, and potential food safety issues, ultimately affecting consumer’s health and satisfaction including the industry's economic viability. Understanding the effects of period of storage on the quality of kilishi produced with different slurries can provide valuable information or insights that could help optimize production processes, improve storage practices, and ultimately ensure production of product that is nutritious and acceptable by the consumers. Given the growing demand for kilishi, both locally and internationally, ensuring its quality over time is essential for expanding its market and maintaining consumer acceptability. Therefore, this research holds practical significance for the consumer, meat processors, meat industry and economic development in the region. Hence the objective of the study is to evaluate the effects of period of storage on proximate and sensory quality of kilishi produced with different slurries.

1. **Materials and Methods**

**2.1 Study Area and Sources of Experimental Materials**

The research was performed at the Laboratory of Soil Science of the Faculty of Agriculture and Life Sciences, Federal University Wukari, Nigeria. Fresh beef meat, and ingredients such as soybean, bambaranut and groundnut seeds, seasonings, spices and other equipment used in the study were bought at the old market in Wukari Metropolis **of** Taraba State

**2.2 Samples preparation and processing**

**2.2.1 Meat Preparation**

This was done according to the method described by Alamuoye (2019) with little modification. 6 kg of fresh beef from the round of 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 they were sliced along the fibre axis into thin slices of about 2 mm thickness in continuous sheets. The pieces of sliced meat were then sun-dried on a raised platform to avoid microbial contamination. This is the first stage of drying and it 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 for proper drying and to avoid them from getting fixed to the drying surfaces. The dried meat was kept in airtight containers for further processing**.**

**2.2.2 Slurry preparation**

This was done according to the procedure described by Iyiola *et al*. (2021) with little modification. Defatted groundnut paste which is the main ingredient used in the processing of kilishi paste was gotten from the dehulled groundnut seed, roasted for 10-15 minutes and cooled. It was cleaned, and milled into paste with grinding machine. Thereafter, oil was extracted from the milled paste as it was kneaded in a bowl on a table. The defatted groundnut paste gotten after the extraction was used in slurry preparation. The same procedure was used in the preparation of bambaranut and soybean pastes except addition of warm water for easy extraction of their oils. In order to avoid rancidity the pastes were prepared on the day of production. Blended spices and seasonings were added to the resultant pastes from defatted groundnut, bambaranut and soybean respectively, as shown in Table 1. After which, 36 mL of clean water was used to mix the different mixtures using a mortar and pestle until a uniform paste was formed. The slurries were prepared on the day of kilishi production to hinder microbial spoilage and reduce the possible development of rancid flavour

**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 |

**2.2.3 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. In order to allow the slurries to penetrate the sliced beef they were left for 1 hour after which they were carefully spread out on the wooden mat and sundried for 10 - 12 hours. The infused beef slices were then roasted for 5 – 10 minutes to allow the ingredients in the products to fasten to it and destroy any microorganisms that might have contaminated the meat samples during sun drying. The samples were judged adequately dry when they became crispy to the touch and brown. Thereafter, they were cooled on a tray and using different air-tight plastic containers they were packaged and stored for 16 weeks at an ambient temperature of 28±2ºC on a shelf for proximate and sensory analysis.

**2.3 Proximate Analysis of Kilishi**

Proximate analysis was done according to the methods described by AOAC (2006) to determine moisture content, 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. 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 while crude protein of the kilishi samples was determined by Kjeldahl methods as described by ISO 20483(2006).

**2.4. Sensory Analysis of Kilishi**

Sensory analysis was conducted at 1st and 16th weeks of 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. Cabin biscuit and water were served in-between the treatments to clean the mouth so that the taste of a treatment will not affect the taste of another 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.

**2.5 Statistical Analysis**

The data generated were statistically analyzed using 2-way Analysis of Variance (ANOVA) in 2x3 factorial arrangements and the differences in means were separated using Least Significant Difference (LSD). The Statistical package SPSS 20 Version was used for this analysis.

1. **Results and Discussion**

**3.1 Proximate composition**

**3.1.1. Effects of Slurries on Proximate Compositions of Kilishi**

The effects of slurries on proximate compositions of kilishi slurries presented in (Table 2) showed significant difference (*P =* .05) in all the parameters analyzed across the treatment groups except on moisture content, crude protein and nitrogen free extract where no significant difference (*P =* .05) was observed. Generally low moisture content was found on the kilishi samples within the period of storage. However, the highest moisture content was found in kilishi made with soybean slurry (8.10%) which was not significantly (*P =* .05) different from other treatment groups while the lowest moisture content (7.76%) was found in kilishi made with groundnut slurry. The moisture content, ranged from 7.76 to 8.10%. This is lower than the range of 6.00±0.50 – 12.33±0.29% reported by Magawata and Faruk (2014) emphasizing the role of lower moisture in improving shelf stability and minimizing microbial growth. The slightly higher moisture content in kilishi made with soybean slurry may be attributed to the intrinsic properties of soybean seeds, which are known to retain more water during processing compared to groundnut and Bambara nut (Iyiola and Bullus, 2024). The general low moisture content found in this study could be attributed to two steps wise drying which was employed during production. The low moisture content is an indication that the samples were properly dried to hinder microbial growth, proliferation and products spoilage, thereby extending their shelf life (Iyiola *et al*., 2023)

Highest crude protein content was found in kilishi made with groundnut slurry (46.67%), closely followed by kilishi made with Bambara nut slurry (45.77%), while kilishi made with soybean slurry recorded the least crude protein (40.75%). This trend agrees with the findings of Idowu *et al*. (2010), which highlighted groundnut’s superior protein content compared to other legumes. Monitoring protein levels ensures consistency in product quality and nutritional composition (Gómez et al., 2020). Protein content influences the nutritional value and texture of kilishi. The high protein content in kilishi made with groundnut and Bambara nut slurries could contribute in producing protein-dense kilishi, as noted by Magawata and Faruk (2014) who also reported that kilishi prepared with protein-rich slurries resulted in a higher crude protein percentage, enhancing its nutritional value. Studies have shown that kilishi contain high crude protein level of 63.4% making it a significant source of dietary protein for consumers (Adeyeye *et al*, 2020). Protein is crucial for building and repairing tissues, growth and immune function (Biesalski, 2005). The range of crude protein content (40.75-46.67%) in this study is lower than the range of 48.19 to 51.04% reported by Olusola *et al*. (2012), 51.62 to 55.84% reported by (Iheagwara and Okonkwo 2016) and 66.61 to 69.92% reported by (Iyiola *et al*., 2021) and 51.95 to 68.17% reported by Iyiola and Aladi (2023).

The crude fat content was significantly (*P* = .05) higher in kilishi made with groundnut slurry (16.18%) than in kilishi made with soybean slurry (11.91%). Kilishi made with Bambara nut slurry (9.98%), had the least fat content due to bambaranut slurry low-fat composition (Iyiola and Bulus, 2024). This is consistent with Opio and Photchanachai (2018), who reported groundnut as a legume with lipid-rich composition, ranging from 40–50%. Therefore the fat content in this study ranged from 9.98 – 16.18%. The reduced fat content in kilishi made with Bambara nut and soybean slurries offer low-fat options for consumers that prefer low fat products due to health related issue that associate with consumption of animal fat product (Iyiola and Aladi, 2023; Youl *et al*., 2012). The high fat content found in kilishi made with groundnut slurry could enhance its sensory quality because fat has been reported to be related to flavor, juiciness and tenderness of a product (Resconi *et al*., 2013). According to Iyiola and Bulus.(2024), kilishi rich flavour is attributed to its moderate fat content (13.44 to 14.90%) The range of fat content in this study is lower than the range of (17.34 – 19.20%) reported by Iheagwara and Okonkwo (2016), 25.36% ± 11.35 reported by Jones *et al*., (2001) and 17.91% - 18.31% reported by Igwe *et al*. (2015). Kilishi’s fat content may offer vital fatty acids which are energy sources and membrane constituents necessary to influence cell and tissue metabolism, function, and responsiveness to hormonal and other (Calder, 2015)

Crude fiber content in this study ranged from 1.81 to 2.55% which differ significantly (P<0.05) and was higher in kilishi made with Bambara nut slurry (2.55%) than in kilishi made with soybean (2.05%) and groundnut (1.81%) slurries. Meat has no or little crude fiber content. Therefore, crude fiber content found in this study could be attributed to the slurry ingredients used during production which are of plant origin (Olusola *et al*., 2017). The variations observed in the crude fibre contents of the samples could be attributed to the chemical composition of the slurries used (Iyiola and Bulus, 2024). This result aligns with Olanrewaju (2022), who noted Bambara nut's high fiber composition, supporting its use in functional food formulations. The range of crude fiber in this study is higher than the range of 0.33 to 0.58% reported by Olusola *et al*. (2017).

Ash content was similar in kilishi made with Bambara nut (5.85%) and soybean (5.83%) slurries but significantly higher than kilishi made with groundnut slurry (5.15%). This also could be attributed to the chemical composition of the slurry used Bambaranut and soybean slurries have been reported to have higher ash contents compared to groundnut slurry (Iyiola and Bulus, 2024) which could have contributed to their higher ash contents, These findings is in agreement with Idowu *et al*. (2010) which emphasized the mineral richness contributed by legumes in kilishi production. Minerals from ash content are essential for dietary balance and health. Mgbemere *et al*. (2011) reported ash range of 4.54 to 3.50% in kilishi which is lower than the range of ash content found in this study.

Nitrogen-free extract (NFE), representing carbohydrate content, was highest in kilishi made with soybean slurry (31.36%), followed by kilishi made with Bambara nut slurry (27.95%) while kilishi made with groundnut slurry had the lowest NFE content (22.44%), The high NFE found in kilishi made with soybean and bambaranut slurries could be attributed to the chemical composition of the slurries used (Iyiola and Bulus, 2024. Nitrogen-Free Extract (NFE) in kilishi made with soybean slurry found in this study is higher than the range of 26–30% reported by Magawata and Faruk (2014) and 19.12% reported by Iyiola *et al*. (2023). This makes soybean slurry a suitable choice for producing energy-rich kilishi, appealing to physically active consumers or those requiring high-energy snacks. The variations in the nutritional composition of kilishi varies could be due to different slurries used (Iyiola *et al*., 2021)

**Table 2. Effects of slurries on Proximate Composition of the Kilishi made with Different Slurries**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | Kilishi made with Groundnut slurry (%) | Kilishi made with Bambaranut slurry (%) | Kilishi made with Soybean slurry (%) | SEM | P. Value |
| Moisture | 7.76 | 7.90 | 8.10 | 0.24 | 0.62 |
| Crude Protein | 46.67 | 45.77 | 40.75 | 4.83 | 0.66 |
| Fat | 16.18a | 9.98b | 11.91b | 0.67 | 0.00 |
| Crude Fiber | 1.81b | 2.55a | 2.05ab | 0.16 | 0.02 |
| Ash | 5.15b | 5.85a | 5.83a | 0.18 | 0.03 |
| NFE | 22.44 | 27.95 | 31.36 | 4.55 | 0.40 |

abMeans in the same row with different superscripts are significantly different (*P* = .05),

SEM: Standard Error of Mean, NFE – Nitrogen Free Extract

**3.1.2. Effect of Period of Storage on the Proximate Composition of Kilishi**

The effect of period of storage on the proximate composition of kilishi presented in (Table 3) showed significant difference (*P* = .05) in most of the parameters except in crude protein and nitrogen free extract content where no significant difference (*P* = .05) was found, As the kilishi samples were stored from 1 – 16 weeks, moisture content, crude protein and crude fiber significantly (*P* = .05) increased while significant (*P* = .05) reduction was seen in fat, ash and Nitrogen free extract content. Moisture content increased significantly (*P* = .05) from 5.85% at 1st week to 9.99% at 16th weeks due to moisture reabsorption from the environment over time. This trend aligns with findings by Magawata and Faruk (2014); Iyiola and Aladi (2023), who reported similar moisture increase in dried meat products and kilishi during extended storage due to environmental absorption. Moisture content is a critical factor influencing the texture, flavor, and shelf life of kilishi (Inusa and Muhammad, 2021). Elevated moisture levels can affect kilishi’s shelf stability by increasing susceptibility to microbial growth, emphasizing the need for optimal storage conditions. However, the moisture content found during the period of storage is low to hinder microbial growth and this could be due to stepwise drying used during production. The moisture range in this study is lower than the range of 5.19 to 7.92 % reported by Olusola *et al*. (2017).

Crude protein content showed no significant differences (*P* = .05), remaining relatively stable at 1st and 16th weeks of storage (44.31% and 44.48%) respectively. This suggested that protein was not degraded during storage. This could be due to drying techniques and low moisture content which enables high concentration of protein on the samples. This stability is consistent to the findings of Idowu *et al*. (2010) and Iyiola *et al*. (2023), who noted that protein in kilishi is well-preserved during storage due to its low moisture content and drying techniques. Protein retention ensures that kilishi continues to serve as a nutrient-dense snack over extended storage periods, Okonkwo *et al*. (2013) reported that Kilishi retains a high protein content, ranging from 40 to 71%, even after prolonged storage while high protein content which ranges from 61.82– 65.91% was reported by Alamuoye (2019).

Crude fat content decreased significantly (P = .05) from 14.34% at 1st week to 11.04% at 16th weeks. This could be attributed to lipid oxidation during storage which could be caused by high temperatures, oxygen exposure, and light which can accelerate fat degradation leading to the formation of off-flavors and unpleasant odors and reducing consumer’s acceptability (Casaburi *et al*., 2015). This reduction aligns with Iyiola *et al*. 2023; Okonkwo *et al*. (2013), who attributed similar decrease in fat to lipid oxidation during storage. Lower fat contents at 16th weeks may affect kilishi's flavor and energy density since fat is related to flavour (Ojo *et al*., 2002; Resconi *et al*., 2013), highlighting the importance of proper packaging to reduce oxidation.

Crude fiber content increased significantly (*P* = .05) from 1.67% at 1st week to 2.60% at 16th weeks. Meat which is the main component of kilishi has no crude fiber content. However, the crude fiber of kilishi is mainly from the ingredients used in its production which are of plants origin (Olusola *et al*., 2018). The increase in crude fibre could be due to concentration effects of the slurries as they integrated into the samples during storage as non-degradable fiber components become more pronounced over time and may impact texture, making kilishi tougher and less palatable over time. This rise is similar with the findings of Iyiola and Bullus (2024), who observed a range of 1.38 to 2.10% of crude fibre. Elevated fiber levels may enhance the functional and health benefits of kilishi, especially to consumers that prefer high-fiber diets.

Ash content decreased significantly (*P* = .05) from 1St – 16th weeks of storage (6.20 – 5.02%) respectively, indicating a reduction in mineral concentration during storage. This decline may result from volatilization or degradation of mineral-rich components, as noted in earlier studies by Idowu *et al*. (2010); Iyiola and Aladi (2023). Rodriguez-Estrada *et al*. (1997) also reported adverse changes leading to decrease in the nutritional value, particularly of mineral and vitamin and changes in the composition of fatty acid. Lower ash content could slightly reduce kilishi's contribution to dietary mineral intake over extended storage. The range of ash content (5.02 – 6.20) of kilishi in this study was lower than the range values of 6.75 – 9.5% reported by Jonathan *et al*. (2016), 9.55% reported by Iheagwara *et al*. (2019) and 4.60 – 10.08% reported by Iyiola and Aladi (2023).

Nitrogen-free extract (NFE), representing carbohydrate content, showed no significant differences (*P* = .05) over the period of storage, with values of 27.63% at 1st week and 26.87% at 16th weeks. This stability suggests that the carbohydrate components in kilishi were not significantly degraded or lost during the 16-week period due to the low moisture content and absence of enzymatic or microbial activity. The drying process effectively reduces water activity, preventing microbial fermentation or hydrolysis of carbohydrates, thereby maintaining the NFE levels throughout storage. This is in agreement with observations by Magawata and Faruk (2014), who found that carbohydrates in kilishi remain consistent during storage having his result ranging from 8.25 to 8.40%, maintaining its role as an energy-dense snack.

**Table 3 Effect of Period of Storage on the Proximate Composition of Kilishi**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Period (Wks) | 1st week (%) | 16th weeks (%) | SEM | P. Value |
| Moisture | 5.85b | 9.99a | 0.20 | 0.00 |
| Crude Protein | 44.31 | 44.48 | 3.94 | 0.98 |
| Crude fat | 14.34a | 11.04b | 0.54 | 0.00 |
| Crude Fiber | 1.67b | 2.60a | 0.13 | 0.00 |
| Ash | 6.20a | 5.02b | 0.14 | 0.00 |
| NFE | 27.63 | 26.87 | 3.72 | 0.89 |

abMeans in the same row with different superscripts are significantly different (p<0.05),

SEM: Standard Error of Mean, NFE: Nitrogen free extract

**3.1.3 Interaction effect of period of storage and slurry types on the proximate composition of kilishi**

The interaction effect of period of storage and slurry types on the proximate composition of kilishi presented in (Table 4) showed significant effect (*P* = .05) except on crude protein and Nitrogen free extract where no significant effect (*P* = .05) was observed. The moisture content increased significantly (*P* = .05) across the slurry types from 1st week to 16t weeks of storage with kilishi made with groundnut slurry increased from 5.98 to 9.54%, kilishi made with Bambara nut from 5.43 to 10.37%, and kilishi made with soybean slurry from 6.13 to 10.07% . The increase was due to the varying water-binding capacities of the ingredients. This increase aligns with findings by Opio and Photchanachai (2018), who emphasized the role of moisture absorption during storage due to environmental exposure. However, According to Chukwu and Imodiboh (2009), when a lean meat is dried to about 20% of moisture it inhibits most bacteria, yeasts and moulds growth while a level of 15% moisture inhibits only some species of fungi. Therefore, the moisture content observed in this study is low which indicates that the samples were properly dried to hinder microbial growth and spoilage over the storage periods. Moisture content is a critical factor influencing texture flavour and shelf life of kilishi (Inusa and Muhammad, 2021). Moisture contents found in this study is very low when compared to 60% moisture content of fresh meat (Afifah *et al*., 2021) indicating the importance of drying method in extending shelf life (Ryoba *et al*., 2013)

Crude protein content displayed no significant differences (*P* = .05) over the interaction effect of period of storage and slurry types across the kilishi samples. Kilishi made with groundnut slurry contained the highest crude protein content at 1st week (49.64%) but reduced to 43.70 at 16th weeks, while kilishi made with soybean slurry recorded the lowest at 1st week (34.72%) but increased to 46.78% at 16th weeks of storage. Reduction in crude protein content found in kilishi made with groundnut and bambaranut slurries during the period of storage could result from protein degradation due to prolonged exposure to light and also increase in moisture content during storage. This agrees with Iyiola and Aladi (2023) who reported decrease of crude protein over a period of storage. However, Increase in crude protein content found in kilishi made with soybean slurry having the highest crude protein at 16th weeks of storage could be due to oxidative stability of the slurry over time. This aligns with studies by Idowu *et al*. (2010); Iyiola and Bulus (2024), which noted that protein retention in dried meat products depends on storage conditions, slurry composition, and oxidative stability. Additionally the high protein content observed in this study is attributed to the lean meat and slurry composition. This is in agreement with studies that have shown that high crude protein content of kilishi could be attributed to the lean meat and the addition of protein rich leguminous plants making it a significant source of dietary protein for consumers (Iheagwara *et al*., 2016, Iyiola and Bulus, 2024).

Contrarily, crude fat content showed a variable trend, with kilishi made with groundnut slurry increasing significantly (*P* = .05) from 14.90 to 17.46% (1st – 16th weeks), while kilishi made with Bambara nut and soybean slurries decreased significantly (*P* = .05) within the period of storage with kilishi made with Bambara nut slurry showing drastic reduction from 14.69 to 5.27%. The decline in fat content of kilishi made with Bambara nut and soybean slurries could be due the capacity of the fat contents of the slurries to leach away during storage causing the overall reduction of the fat content of the final product. This is similar to Idowu *et al*. (2010) who attributed such reductions to lipid oxidation or rancidity during prolonged storage. Groundnut’s higher lipid stability may be due to its natural antioxidant content, as previously highlighted by Opio and Photchanachai (2018), who reported that groundnut contains significant amounts of natural antioxidants, such as polyphenols, tocopherols (vitamin E), and flavonoids, which help prevent lipid oxidation and rancidity in food products. The range of fat content in this study is lower than 17.34 – 19.20% reported by Iheagwara and Okonkwo (2016), 25.36 ± 1.69% reported by Jones *et al*., (2001) and 17.91 - 18.31% reported by Igwe *et a*l. (2015.) but higher than 10.11 – 10.57% reported by Iheagwara *et al*. (2019). The highest fat contents found in kilishi made with groundnut slurry could enhance its sensory qualities (Resconi *et al*., 2013) but less preferred by consumers that like low fat meat products due to health related issues associated to consumption of animal fat products.

Crude fiber content increased significantly (P = .05) across all the slurry types kilishi within the period of storage, with Bambara nut slurry showing the highest values (2.10 and 3.00%) at both 1st and 16th weeks respectively. Crude fiber in kilishi represents the indigestible portion of plant material present in the leguminous plants, spices and seasoning used during its preparation Therefore this increase may be attributed to the chemical composition of the slurry since it was of plant origin and also to the relative concentration effect of the slurries during storage as they migrated into the meat as other components such as moisture and ash fluctuate, Small amount of crude fiber in kilishi, can aid in enhancing the overall digestive benefits of the product (Inusa and Muhammad, 2021)

Ash content decreased over time for all slurry types kilishi, with the most notable drop observed in kilishi made with groundnut slurry (5.77 to 4.53%). This decline could be attributed to leaching or breakdown of mineral-rich components during storage. Kilishi made with soybean slurry retained higher ash content (6.51 to 5.16%) compared to other treatment groups, supporting findings by Idowu *et al*. (2010), who emphasized the mineral contribution of soybean in food products having high in kilishi (7.10%) when compared with fresh meat. Ash content in food represents the total mineral composition, which plays a vital role in bone formation, enzyme activation, fluid balance, and overall metabolic functions in the human body (Soetan *et al*., 2010) Nitrogen-free extract (NFE), representing carbohydrate content, showed minimal variation especially in kilishi made with groundnut slurry and no significant differences (*P* = .05) over the storage period across slurry types. The highest NFE (37.67%) was found in kilishi made with soybean slurry at 1st week while a notable increase in NFE from 22.89 to 33.02% was observed in kilishi made with Bambara nut slurry within the period of storage. The highest NFE found in kilishi made with soybean slurry at 1st week of storage could be attributed to the ability of the dried meat sample to absorb the slurry compare to other kilishi samples this agrees with the report of Olusola *et al*. (2017) who reported varied rate of absorption and adsorption of the dried raw meat slices in the slurry. Additionally the most notable increase in NFE found in kilishi made with Bambara nut slurry could be attributed to a relative concentration of carbohydrates from the slurry to the meat during storage. This aligns with Magawata and Faruk (2014), who observed similar increase in NFE during storage which ranged around from 0.67 – 2.17%. The spices and seasonings used in kilishi preparation, such as groundnut or bambaranut paste and other ingredients, add to the carbohydrate content, thereby enhancing its nitrogen free extract concentration (Iyiola *et al*. 2025). This carbohydrate component plays a crucial role in providing the caloric value of kilishi, making it not only a protein-rich snack but also a substantial energy provider.

**Table 4: Interaction Effect of Period of Storage and Slurry Types on Proximate Composition of Kilishi**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Slurry | Kilishi made with Groundnut slurry (%) | | Kilishi made with Bambaranut slurry (%) | | Kilishi made with Soya bean slurry (%) | | SEM | P-value |
| Period of Storage  (wks) | **1** | **16** | **1** | **16** | **1** | **16** |  |  |
| Moisture | 5.98b | 9.54a | 5.43b | 10.37a | 6.13b | 10.07a | 0.34 | 0.05 |
| Crude Protein | 49.64 | 43.70 | 48.57 | 42.98 | 34.72 | 46.78 | 6.83 | 0.35 |
| Fat | 14.90ab | 17.46a | 14.69ab | 5.27d | 13.44b | 10.38c | 0.94 | 0.00 |
| Crude fiber | 1.38d | 2.23bc | 2.10bc | 3.00a | 1.53cd | 2.57ab | 0.23 | 0.05 |
| Ash | 5.77ab | 4.53c | 6.33a | 5.37b | 6.51a | 5.16bc | 0.25 | 0.05 |
| NFE | 22.33 | 22.54 | 22.89 | 33.02 | 37.67 | 25.04 | 6.44 | 0.25 |

abcdmeans in the same row with different superscripts are significantly different (p<0.05),

SEM: Standard Error of Mean, NFE: Nitrogen free extract

**3.2 Sensory Quality**

**3.2.1 Effects of Slurries on Sensory Quality of Kilishi**

The effect of slurries on sensory quality of kilishi is shown in (Table 5). A significant effect (*P* = .05) was observed in overall appearance, juiciness and overall acceptability while no significant effect was observed in colour, flavour, and tenderness across the treatment groups. The overall appearance of kilishi made with groundnut slurry was rated highest (7.60) compared to kilishi made with Bambara nut slurry (6.40) and kilishi made with soybean slurry (6.35), with the latter showing a significantly (*P* = .05) lower score. The highest score of overall appearance found in kilishi made with groundnut slurry could be attributed to its higher fat content (Table 2) which enhances the surface shine and improves the appealing golden-brown color of kilishi after drying (Egbo *et al*., 2001). Kilishi made with groundnut slurry's higher rating aligns with its established role in enhancing visual appeal due to its natural color and binding properties, as noted by Magawata and Faruk (2014). Appealingly pleasing products often gain higher consumer acceptance, underscoring kilishi made with groundnut slurry's advantage in this aspect.

The color scores showed no significant differences among the kilishi samples, with values which ranged from 6.05 to 6.55 across the kilishi samples. This consistency may result from the uniform drying and roasting processes applied across treatments. These findings align with Idowu *et al*. (2010), who observed minimal color variation in kilishi produced using different slurry formulations. Meat colour is one of the most important sensory characteristics by which consumers make judgments on meat quality (Ruiz-Capillas, *et al*., 2021).However, the highest score found on the colour of kilishi made with groundnut slurry could be attributed to higher oil content of the slurry (Iyiola and Bulus. 2024) which enhances the surface shine and improves the appealing golden-brown color of kilishi after drying (Egbo *et al*., 2001).

Flavor was rated highest for kilishi made with groundnut slurry (7.05), with kilishi made with Bambara nut (6.85) which showed comparable results and kilishi made with soybean which had the least score (6.05). The flavor profile of kilishi is significantly influenced by its fat content, which enhance the release of aromatic compounds during roasting (Idowu *et al*., 2010). Kilishi made with groundnut slurry's superior fat content (Table 2) likely contributed to its higher flavor rating, consistent with earlier observations by Opio and Photchanachai (2018) on the sensory impact of lipid-rich ingredients.

Tenderness scores ranged from 5.75 to 6.65 for the kilishi samples with no significant differences. The highest crude fibre content (6.65) was found in kilishi made with bambaranut slurry (6.65) while kilishi made with soybean slurry has lowest tenderness score (5.75) which may be attributed to its lower fat content, which can affect the mouthfeel of kilishi (Iyiola and Bullus, 2024. Additionally, the highest crude fibre content found in kilishi made with bambaranut slurry could likely be due to its higher fiber and moisture retention properties, which prevent excessive drying and hardening of the meat. This implies that kilishi made with Bambara nut slurry was tenderer compared to other samples which could be appealing to consumers that prefer tender meat products. This agrees with the report of Iyiola and Bulus (2024) who reported higher tenderness score in kilishi made with bambaranut slurry. Similarly Aworh (2023) reported that excessively tough or dry kilishi was less preferred.

Juiciness was significantly (*P* = .05) higher in kilishi made with groundnut slurry (6.85) compared to kilishi made with soybean slurry which made least score (5.35), with kilishi made with Bambara nut slurry showing intermediate results (6.45). Kilishi made with groundnut slurry’s higher fat content (Table 2) likely enhanced the perception of juiciness, this agrees with Kumar *et al*. (2017) on the role of fats in improving sensory qualities. Resconi *et al*., (2013) also reported on fats ability to enhance juiciness and flavor.

In addition, overall acceptability followed a similar trend, with kilishi made with groundnut slurry having the highest score (7.55), followed by kilishi made with Bambara nut (6.90) and soybean (5.75) slurries, with a significant difference (*P* = .05) observed between kilishi made with groundnut and soybean slurries. These scores reflect consumer preference for the well-rounded sensory qualities provided by kilishi made with groundnut slurry, agreeing findings by Idowu *et a*l. (2010); Magawata and Faruk (2014). The overall acceptability of kilishi made with groundnut slurry is generally high due to its unique combination of flavor, texture, colour and appearance (Ref ).

**Table 5: Effects of Slurries on Sensory Quality of Kilishi**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | Kilishi made with Groundnut slurry | Kilishi made with Bambaranut slurry | Kilishi made with Soya bean slurry | SEM | P-value |
| Overall Appearance | 7.60a | 6.40ab | 6.35b | 0.43 | 0.05 |
| Colour | 6.55 | 6.40 | 6.05 | 0.43 | 0.70 |
| Flavour | 7.05 | 6.85 | 6.05 | 0.36 | 0.12 |
| Tenderness | 6.30 | 6.65 | 5.75 | 0.39 | 0.26 |
| Juiciness | 6.85a | 6.45ab | 5.35b | 0.45 | 0.05 |
| Overall Acceptability | 7.55a | 6.90a | 5.70b | 0.27 | 0.00 |

abmeans in the same row with different superscripts are significantly different (p<0.05),

SEM: Standard Error of Mean

**3.2.2 Effect of Period of Storage on the Sensory Quality of Kilishi**

The effect of period of storage on the sensory quality of kilishi, as presented in (Table 6), indicated minor changes in sensory attributes over time, with no significant differences on all the parameters analyzed. This stability underscores the resilience of kilishi's sensory properties during extended storage when appropriate production and storage practices are applied. Overall appearance scores of the kilishi samples slightly increased within the period of storage from 6.67 at 1st week to 6.90 at 16th weeks. This minor improvement could be attributed to the continued integration of slurry components into the kilishi matrix during storage, enhancing visual appeal. Similar findings were reported by Petrova *et al*., (2015), who noted that well-processed kilishi retains its appearance due to its dried surface and lipid content.

Color ratings of the kilishi samples also showed a slight increase within the period of storage from 6.20 at 1st week to 6.47 at 16th weeks. The uniformity in color may result from effective drying and roasting techniques, which fix the surface color and resist pigment degradation over time. This stability reflects the minimal impact of storage on kilishi’s pigmentation. This is consistent with observations by Idowu *et al*. (2010) who reported that kilishi maintains its color stability during storage due to the drying and roasting processes, which help fix surface pigments and reduce oxidative discoloration over time. Contrarily, Yusuf *et al*. (2020) reported that color of kilishi may darken slightly during storage due to oxidation and exposure to air, which affects its visual appeal,

Furthermore, flavor scores of the kilishi samples slightly decreased from 6.77 at 1st week to 6.53 at 16th weeks of storage, though not significantly. This minor decline could be linked to lipid oxidation or reduction of fat content during storage (Table 3) as noted by Petrova *et al*., (2015). Similarly, Kovac *et al*. (2020).reported that fat oxidation negatively impacts the flavor by producing off-flavors and reducing overall consumer acceptability. Prolonged exposure to air which can cause the spices to lose potency, leading to a blander taste in kilishi was reported by Igene and Mohammed (2014). However, kilishi’s low moisture content likely inhibits significant flavor deterioration, a finding supported by Kumar *et al*. (2017), who emphasized the role of drying in preserving meat flavor during storage. The range of flavour found in this study is higher than 6.1 – 6.3 reported by Aladi *et al*. (2022) but lower than 7.82 – 8.43 reported by Iheagwara and Okonkwo (2016).

Similarly, tenderness scores modestly declined within the period of storage from 6.50 at 1st week to 5.97 at 16th weeks, reflecting the slight toughening of the kilishi over time which is primarily due to protein cross-linking, and oxidative changes. This trend is consistent with reports Iyiola and Bullus (2024), who observed reduction in tenderness in dried meat products due to moisture redistribution and changes in protein structure. Kilishi tends to become tougher and drier as moisture is gradually absorbed from the environment, despite the initial dehydration process (Shamsuddeen, 2009). Therefore, prolonged storage can lead to a reduction in tenderness and juiciness, making the product less palatable over time. The range of tenderness in this study is higher than 2.80 – 3.60 reported by Alamuoye (2019) but lower than the range of 7.04 – 7.62 reported by Ihegwara and Okonkwo (2016) and 5.20 – 6.93 reported by Iyiola and Aladi (2023)

Additionally, juiciness ratings also exhibited a slight decline over the period of storage, from 6.40 at 1st week to 6.03 at 16th weeks. This is primarily caused by reduction of fat (Table 3) due to fat oxidation. This is similar to the report of Gomez *et al* (2020) who stated that reduction of fat in meat products can result to loss of juiciness and obtaining a hard and rubbery texture. Despite this decline, the changes are not significant, indicating that kilishi retains acceptable levels of juiciness over the period of storage. The range of juiciness in this study is lower than the range of 6.58 – 7.23 reported by Iheagwara and Okonkwo (2016) and 6.20 – 7.20 reported by Alamuoye 2019

Overall Acceptability scores remained stable, increasing slightly from 6.67 at 1st weeks to 6.80 at 16th weeks. This consistency suggests that kilishi maintains its appeal to consumers throughout the period of storage, which could be attributed to proper storage condition and spices acting as antioxidant and antibacterial to the samples (Zhang *et al*., 2019). Magawata and Faruk (2014), also emphasized the role of proper processing and storage conditions in preserving product quality.

**Table 6: Effect of Period of Storage on Sensory Quality of Kilishi Produced with Different Slurries**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Period of storage | 1st week | 16th weeks | SEM | P-value |
| Overall Appearance | 6.67 | 6.90 | 0.35 | 0.64 |
| Colour | 6.20 | 6.47 | 0.35 | 0.59 |
| Flavour | 6.77 | 6.53 | 0.29 | 0.57 |
| Tenderness | 6.50 | 5.97 | 0.32 | 0.24 |
| Juiciness | 6.40 | 6.03 | 0.37 | 0.48 |
| Overall Acceptability | 6.67 | 6.80 | 0.27 | 0.72 |

abMeans in the same row with different superscripts are significantly different (p<0.05),

SEM: Standard Error of Mean

**3.2.3 Interaction Effects of Period of Storage and Slurry Types on the Sensory Quality**

The interaction effects of period of storage and slurry types on the sensory quality of kilishi presented in (Table 7) showed, significant (*P* = .05) interaction effect on overall appearance, juiciness and overall acceptability of the kilishi samples while no significant interaction effect was observed on colour, flavour and tenderness across the treatment groups. Overall appearance of kilishi made with groundnut slurry improved slightly from 7.30 at 1st week to 7.90 at 16th weeks of storage, indicating enhanced visual appeal during storage. Conversely, kilishi made with Bambara nut slurry showed a slight decrease from 6.60 to 6.20, while kilishi made with soybean slurry demonstrated a significant increase (*P* = .05) from 6.10 to 6.60 within the period of storage. Increase in overall appearance of kilishi made with groundnut and soybean slurries could be attributed to their fat contents (Table 2). These changes align with findings by Iyiola and Bulus (2024) who noted that lipid content in groundnut-based products contributes to sustained visual appeal during storage. This indicates that kilishi made with groundnut and soybean maintained their appearance over time compare to kilishi made with bambaranut slurry

Color ratings showed no significant differences (P>0.05) across storage periods for all slurry types kilishi ranging from 5.90 to 6.70. Increase in colour of the samples was found within the period of storage. Color is an important factor in kilishi’s evaluation, as it indicates freshness and the extent of drying or roasting This stability of colour observed in this study suggests that the drying and roasting processes used in kilishi production play a dominant role in determining color, as also highlighted by Idowu *et al*. (2010). Therefore, consistency in color ratings reflects no pigment degradation during storage rather pigment concentration was enhanced and the colour deepen which can be attributed to Maillard browning reactions and moisture loss. The range of colour ratings observed in this study is similar to the range of 5.27 – 6.73 reported by Iyila and Aladi (2023)

Flavor of the kilishi samples were similar across storage periods, with no significant differences across the treatment groups. Kilishi made with groundnut slurry had the highest flavor scores (7.30) at 1st week and decreased (6.80) at 16th weeks while kilishi made with soybean slurry recorded the lowest score (6.20) at 1st week and (5.90) at 16th weeks of storage, which could be attributed to the lowest fat content found in kilishi made with soybean slurry within the period of storage (Table 4). leading to less flavor retention and intensity during storage (Rescomi *et al*., 2013) and natural oils in groundnut, which act as flavor carriers, enhanced the perception of taste and aroma over time (Iyiola. And Bulus, 2024). These results align with Opio and Photchanachai (2018), who noted that the lipid profile of groundnut enhances flavor retention during storage.

Furthermore, tenderness declined within the period of storage for kilishi made with groundnut slurry from 6.80 at 1st week to 5.80 at 16th weeks. Kilishi made with Bambara nut slurry showed a smaller decrease (6.90 to 6.40), while soybean slurry maintained consistently lower scores (5.80 to 5.70). The decline in tenderness of kilishi during storage is primarily due to moisture loss, protein cross-linking, and oxidative changes. As storage progresses, dehydration leads to increased muscle fiber rigidity, while protein-protein interactions and lipid oxidation further contribute to texture hardening. This aligns with Kumar *et al*. (2017), who observed that prolonged storage can reduce tenderness due to moisture loss or protein structure changes.

Juiciness decreased significantly (*P* = .05) for all slurry types kilishi over the storage period. Kilishi made with groundnut slurry experienced a moderate decline from 7.20 to 6.50, while kilishi made with Bambara nut and soybean slurries declined more sharply, from 6.90 to 6.00 and 5.10 to 5.60, respectively, the reduction in juiciness over time is primarily caused by lipid oxidation, and protein denaturation, which leads to a drier texture and reduced water-holding capacity in kilishi. These trends align with Iyiola *et al*. (2025), who attributed reductions in juiciness to moisture redistribution and lipid oxidation during storage.

Overall Acceptability remained high for kilishi made with groundnut slurry (7.60 and 7.50 at 1st and 16th weeks) respectively while kilishi made with Bambara nut slurry showed a significant (*P* = .05) increase (6.60 to 7.20). Kilishi made with soybean slurry had the lowest ratings, declining significantly (*P* = .05) from 5.80 at 1st week to 5.70 at 16th weeks. This highest score of overall acceptability found in kilishi made with groundnut slurry can be attributed to their rich flavor, higher fat content, and better texture retention, which enhance taste, mouth feel, and consumer preference. These findings underscore kilishi made with groundnut slurry's ability to sustain consumer preference during storage, consistent with Iyiola and Bullus (2024), who emphasized groundnut’s superior sensory attributes in kilishi production.

**Table 7: Interaction Effects of Period of Storage and Slurry Types on Sensory Quality of Kilishi**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Slurry types | Kilishi made with  Groundnut slurry | | Kilishi made with  Bambaranut slurry | | Kilishi made with  Soyabean slurry | | SEM | P-value |
| Period of  Storage (wks) | **1** | **16** | **1** | **16** | **1** | **16** |  |  |
| Overall  Appearance | 7.30ab | 7.90a | 6.60ab | 6.20ab | 6.10b | 6.60ab | 0.61 | 0.05 |
| Colour | 6.40 | 6.70 | 6.30 | 6.50 | 5.90 | 6.20 | 0.61 | 1.00 |
| Flavour | 7.30 | 6.80 | 6.80 | 6.90 | 6.20 | 5.90 | 0.50 | 0.83 |
| Tenderness | 6.80 | 5.80 | 6.90 | 6.40 | 5.80 | 5.70 | 0.54 | 0.71 |
| Juiciness | 7.20a | 6.50ab | 6.90a | 6.00ab | 5.10b | 5.60ab | 0.55 | 0.05 |
| Overall  Acceptability | 7.60a | 7.50a | 6.60ab | 7.20a | 5.80b | 5.70b | 0.63 | 0.05 |

abMeans in the same row with different superscripts are significantly different (p<0.05),

SEM: Standard Error of Mean

**4.0 Conclusion**

The results revealed that period of storage significantly influenced the proximate composition of kilishi produced with different slurries. Moisture content increased across all slurry kilishi, with kilishi made with Bambara nut slurry having the highest moisture content. Crude fat content significantly decreased in kilishi made with Bambara nut and soybean slurries, indicating lipid oxidation as a factor during extended storage. Crude protein and nitrogen-free extract (NFE) remained stable, ensuring that kilishi retained its nutritional value as a protein- and energy-rich snack. Ash content slightly decreased reflecting minor mineral losses, while crude fiber increased in all the kilishi samples, enhancing their functional properties. The sensory evaluation demonstrated that kilishi maintained its sensory appeal over the 16th weeks of storage with minimal declines in attributes such as flavour, juiciness and tenderness. Kilishi made with groundnut slurry consistently outperformed the other slurry types kilishi in flavor, juiciness, and overall acceptability, retaining its sensory quality more effectively during storage. Kilishi made with Bambara nut slurry provided intermediate performance, while kilishi made with soybean slurry showed least sensory appeal, particularly in flavor and juiciness. Despite slight changes, overall acceptability scores for kilishi remained high especially in kilishi made with groundnut slurry, emphasizing its resilience to quality degradation during storage. Therefore bambaranut slurry can serve as viable alternative in kilishi production, offering nutritional and sensory stability similar to kilishi made with groundnut slurry

**Ethical Approval**

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.

**References**

1. Hawkes, C., Harris, J., & Gillespie, S. (2017) Urbanization and the Nutrition Transition. In Global Food Policy Report, (4) pp. 34-41. <https://doi.org/10.2499/9780896292529_04>
2. Tarrant, P. V. (1998). Some recent advances and future priorities in research for the meat industry. *Meat Science*, 49, 1- 16. <https://doi.org/10.1016/S0309-1740(98)90035-3>
3. 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. <https://doi.org/10.3389/fnut.2022.1057366>
4. Ryoba, R. N., Mulikambele, V. R., Mtenga, L. A., & Mgbeni, D. M. (2013). Comparative assessment of drying methods, curing agents and meat cut size on the quality and preservation of meat under rural setting perspectives. Livestock Research for Rural Development. Vol 25. <http://wwwIrrd.org/Irrd25/1/ryob25010.htm>.
5. 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.
6. Adeyeye, S. A. O. (2016). Safety issues in traditional West African foods: A critical review. *Journal of Culinary Science & Technology*, 15(2), 101-125. DOI: 10.1080/15428052.2016.1225533
7. Iheagwara, M. C., & Okonkwo, T. M. (2016). Effect of processing techniques on the microbiological quality of Kilishi. A traditional Nigerian dried beef product. *Journal of Meat Science and Technology*, 4(1): 11-17. Available at: [www.jakraya.com/journal/jmst](http://www.jakraya.com/journal/jmst).
8. 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.
9. 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.
10. 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.
11. 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.
12. 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. <https://doi.org/10.31248/JASVM2024.470>
13. 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. Pg 742 - 746
14. 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. <https://doi.org/10.33003/jaat.2023.0904.09>
15. Igene, J.O. (1988). Lipid fatty acid composition acid storage stability of Kilishi, a sun dried meat product. *Journal of Tropical Science*, 28, 156 -161. <http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=6927417>
16. 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. <http://www.journalajst.com>
17. 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. [www.afst.valahia.ro](http://www.afst.valahia.ro)
18. 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.[www.foodsciencejournal.com](http://www.foodsciencejournal.com)
19. Association of Official Analytical Chemists (2006).. Official Methods of Analysis. In: Horwitz, W. (ed.), 18th Edition. AOAC Press, Arlington, VA, USA. Pp. 1-48.
20. ISO 20483 (2006): Determination of Nitrogen content and crude protein content- Kjeldahi method. <https://www.iso.org/obp/ui/#iso:std:iso:20483:ed-1:v1:en>
21. 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. : <http://docsdrive.com/pdfs/medwelljournals/jftech/2011/119-123.pdf>
22. Ranganna, S. (2001). Handbook of analysis and quality control for fruits and vegetable products (7th Edition). Tata McGraw Hill Book Co., New Delhi, India. Pp. 594-625.
23. Magawata, I., & Faruk, S. U. (2014). Effect of groundnut and tigernut doughs on the quality of fish Kilishi. *Food Science and Quality Management*, 31, 53–59. <https://core.ac.uk/download/pdf/234683858.pdf>
24. Idowu, A. O., Omobuwajo, T. O., & Falade, K. O. (2010). Production proximate analysis and shelf life studies of ready-to-eat rice and kilishi. *African Journal of Food Science*, 4(5), 264-268. Available online <http://www.academicjournals.org/ajfs>
25. Gómez, I., Janardhanan, R., Ibañez, F.C., & Beriain, J. (2020). The effects of processing and preservation technologies on meat quality: sensory and nutritional aspects. *Foods*, 9, 1416. doi:10.3390/foods9101416
26. Adeyeye, E. I., Adesina, A. J., Olaleye, A. A., Olagboye, S. A., & Olatunya, M. A. (2020). Proximate, vitamins, minerals compositions together with mineral ratios and mineral safety index of Kilishi (beef jerky meat). Haya Saudi J. Life Sci, 5(5), 79-89. DOI: 10.36348/sjls.2020.v05i05.005
27. Biesalski, H. K. (2005). Meat as a component of a healthy diet–are there any risks or benefits if meat is avoided in the diet?. *Meat science*, 70(3), 509-524.. <https://doi.org/10.1016/j.meatsci.2004.07.017>
28. 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 Production Advances*, 2(5), 221-232
29. Opio, P., & Photchanachai, S. (2018). Modified atmosphere influences aflatoxin B1 contamination and quality of peanut (Arachis hypogaea L.) kernels cv. Khon Kaen 84-8. *Journal of Stored Products Research*, 78, 67-73.
30. Youl, P., Baade, P., & Meng, X. (2012). Impact of prevention on future cancer incidence in Australia. *Cancer Forum*, 36(1), 37-41. Available at: <https://search.informit.org/doi/abs/10.3316/informit.131072562035189>
31. Resconi, V. C., Escudero, A., & Campo, M. M. (2013). The development of aromas in ruminant meat. *Molecules*, 18(6), 6748 - 6781. DOI: 10.3390/molecules18066748
32. 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.
33. Calder, P. C. (2015). Functional roles of fatty acids and their effects on human health. *Journal of Parenteral and Enteral Nutrition*, 39, 18-32.https://doi.org/10.1177/0148607115595980
34. Olanrewaju, O. S. (2022). Analysis of Bambara groundnut (Vigna subterranea (L.) Verdc.) diversity towards improved yield." PhD diss., North-West University South Africa . <https://orcid.org/0000-0002-1682-1060>
35. Mgbemere, V. N., Akpapunam, M. A., & Igene, J. O. (2011). Effect of groundnut flour substitution on yield, quality and storage stability of Kilishi. A Nigerian indigenous dried meat product. *African Journal of Food, Agriculture, Nutrition and Development*, 11(2), 4718-4738. <http://ajfand.net/AJFAND/copyrightstatement.html>
36. Inusa, S. K., & Muhammad, B. F. (2021). Evaluation of sensory properties of Kilishi prepared from fermented cattle and camel beef in Semi-arid Nigeria. Nigerian Journal of Animal Production, 48(5), 113-123.https://doi.org/10.51791/njap.v48i5.3191
37. Afifah, N., Ratnawati, L., Indrianti, N., & Sarifudin, A. (2021, November). The effect of pre-drying treatments on the quality of dehydrated ground beef. In IOP Conference Series: Earth and Environmental Science (Vol. 924, No. 1, p. 012006). IOP Publishing.doi:10.1088/1755-1315/924/1/012006
38. Casaburi, A., Piombino, P., Nychas, G. J., Villani, F., & Ercolini, D. (2015). Bacterial populations and the volatilome associated to meat spoilage. *Food Microbiology*, 45, 83-102. <https://doi.org/10.1016/j.fm.2014.02.002>
39. 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.
40. Soetan, K. O., Olaiya, C. O., & Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*, 4(5), 200-222. <http://www.academicjournals.org/ajfs>
41. Iyiola, V. O., Danladi, P., Aladi, N., & Msughter, G. (2025). Effects of meat types on proximate and microbial qualities of suya produced in Wukari Metropolis, Nigeria. Farm Animal Health and Nutrition. 2025; 4(1): 14-20. DOI: 10.58803/fahn.v4i1.71 <http://fahn.rovedar.com/>
42. Jones, M. J., Tanya, V. N., Mbofung, C. M. F., Fonkem, D. N., & Silverside, D. E. (2001). A microbiological and nutritional evaluation of the West African dried meat product, Kilishi. *Journal of food technology in Africa*, 6(4), 126-129. <https://doi.org/10.4314/jfta.v6i4.19304>
43. Egbo, M. L., Bamgbose, A. M., Oyawoye, O. M., & Sani, R. M. (2001). Effect of processing and preservation method on the organoleptic and shelf life of meat products. *Nigerian Journal of Animal Science*, 4(2).155 - 160
44. Ruiz-Capillas, C., Herrero, A. M., Pintado, T., & Delgado-Pando, G. (2021). Sensory analysis and consumer research in new meat products development*. Foods*, 10(2), 429. <https://doi.org/10.3390/foods10020429>
45. Aworh, O. C. (2024). An overview of West African traditional foods: Processing, safety and health benefits. Nutritional and Health Aspects of Food in Western Africa, 1-8. <https://doi.org/10.1016/B978-0-443-27384-1.00006-1>
46. Kumar, P., Chatli, M. K., Verma, A. K., Mehta, N., Malav, O. P., Kumar, D., & Sharma, N. (2017). Quality, functionality, and shelf life of fermented meat and meat products: A review. *Critical Reviews in Food Science and Nutrition*, 57(13), 2844-2856. <https://doi.org/10.1080/10408398.2015.1074533>
47. Petrova, B., Bekhit, A. E. D., Morton, J. D., & Mason, S. L. (2015). Chemical composition and sensory quality of smoked meats. *Food Chemistry*, 174, 294-302.
48. 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. DOI: 10.24018/ejeng.2020.5.4.1864.
49. Aladi, N. O. Iyiola, V. O., Onwudufor, E.O., & Okeudo, N.J. (2022).. Production and evaluation of kilishi-like jerky from chicken. 11th ASAN and NIAS Joint Annual Meeting and 27th ASAN Annual Conference Proceedings Bauchi, Bauchi State Nigeria
50. 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. <https://doi.org/10.4314/bajopas.v2i2.63767>
51. Zhang, D, Gan, R. Y, Farha, A. K., Kim, G., Yang, Q.Q, Shi, et al (2019). Discovery of ntibacterial dietary spices that target antibiotic-resistant bacteria. Microorganisms, 29; 7(6):157. doi: 10.3390/microorganisms7060157.
52. Iyiola, V.O., Obialigwe, T. F., Felix, P., & Adam, U. U. (2025). Evaluation of the shelf life and quality of kilishi prepared with different slurries. *Journal of Animal Science and Veterinary Medicine*, 10(1), 41-49. <https://doi.org/10.31248/JASVM2025.537>