Nigerian J. Anim. Sci. 2023, 25 (1): 193-203

Proximate composition and microbial count of oven dried kilishi like jerkies made from different meat types

Iyiola, V.O.,[1]* Aladi, N.O., [2] Okeudo N.J., [2] Achonwa, C.C.,[2] Ojinnaka, P.E.,[1] Okoli, I.C.[1]

[1]*Department of Animal Production and Health, Federal University Wukari, Nigeria*
[2]*Department of Animal Science and Technology, Federal University of Technology, Owerri*

***Corresponding Author:** +234 8030893878, vivianogechi80@gmail.com*

***Target Audience**: Meat processors and Scientists*

Abstract

The proximate composition and microbial count of traditionally sundried and oven dried kilishi like jerkies made from different meat were compared. The meat samples from beef, chicken and pork were processed into kilishi by oven drying and then analyzed for the proximate and microbial count after 1st and 24th weeks of storage. The data generated were analyzed in a 3x2 factorial arrangement using a completely randomized design (CRD). The results of proximate analysis showed significant effects of the meat types and period of storage in all the parameters analyzed except in moisture content. Beef kilishi was found to have a higher amount of crude protein and fat content compared to other meat types, while higher amounts of ash and nitrogen-free extract were found in chicken and pork kilishi. Microorganisms such as Fungi, Salmonella, E-coli, Staphylococcus and Total coliform were isolated from the treatments. Chicken kilishi had the highest microbial count compared to other treatments. The study indicated that the production of safe, wholesome, and nutritious kilishi meat product can be achieved in the production of kilishi with chicken and pork meats. However, due to the higher microbial counts of chicken kilishi, it is therefore recommended the storage period of chicken kilishi should be minimal.

***Keywords:** Kilishi; beef; chicken; pork; oven dried; microbial*

Description of problem

Kilishi is a traditional sun-dried jerky made largely from beef, mutton or chevon. It is a rich nourishing snack values for peculiar sensory characteristics and good shelf life (7). It is made from thinly sliced fresh lean strips or slice of muscle which is dipped into slurry and sundried (8). Currently, the production is largely in the hands of traditional producers, (9; 10). Well processed kilishi could be stored for more than a year (11; 12). Though demand for kilishi is on the increase in recent times, an increasing attention is also being paid to the effects of diet on human health and well-being with an attendant bias against red meat consumption. Hence, the traditional raw materials used in kilishi production (red meats) are becoming issues of great concern for many consumers. For kilishi production to expand beyond its traditional location and gain wider acceptance, there is need therefore to explore other meats (chicken and pork) and their period of storage that is safe for consumption. This option is highly germane to sustainable production and demand of kilishi within and beyond the sub-Saharan African region which will in turn improve nutrition, enhance wellbeing and attract more investment in the industry.

A critical control point kilishi production is drying which in the traditional setting is achieved largely by sun drying. Drying is one of the oldest methods used in preserving food. It helps to reduce cost of storage and transportation and makes handling easier by reducing size, weight, and risk of microbial contamination of foods (1). Drying increases the shelf life of meat and meat products by hindering the growth of microorganism via reduction in moisture content and water activity (a_w) (2; 3). Drying methods are largely used to produce traditional meat products in large quantities due to their unique flavour such as fermented sausages, dry-cured hams, koppa, speck or pastrami (Europe), Jerky (North America), Bresaola (Italy), Biltong (southern Africa), Odka (Somalia), Kuivaliha (Finland), Qwanta (Ethiopia), Pemmican (Arctic Circle), Carne-de-sol and charqui (Brazil), Kilishi, Balangu (roasted meat), Dan-bu-nama, Tsire, Jirga, Ndako, Banda, Suya, (Nigeria) (4; 5; 6). Sun drying is however not effective in many parts of humid tropics as dry seasons are relatively short and humidity is high in most parts of the year. Incidentally this same region is home to many poultry and swine industry. Therefore, development and/or evaluation of alternative methods of drying kilishi needed for enhanced value addition to poultry and pork in the region. The aim of this study is therefore to compare the proximate composition and microbial count of oven dried kilishi like jerkies made with different meat types (beef, chicken and pork).

Materials and Methods

Source of the meat samples

2kg of beef from the round of freshly slaughtered carcass were sourced at the central abattoir of Owerri Municipal Council. Pork samples were sourced from the ham of reputable vendors in Owerri metropolis and were gotten from freshly slaughtered pigs while the chicken was sourced from matured broiler chicken raised at the FUTO Teaching and Research Farm. Matured broiler chicken was slaughtered and dressed under standard protocols. The breast and thigh muscles were carefully extracted and kept refrigerated for at 10 ℃ for 12 to 15 hours prior to use. The spices and groundnut used for slurry were purchased from grocery shop in Ekeukwu Owerri (Old market)

Groundnut paste preparation

Groundnut paste was produced according to the methods described by (13) with little modification. 150 g of dehulled groundnut seeds were cleaned by hand abrasion, winnowed and the hulls removed. The clean seeds were roasted in the oven for 5 – 10 minutes at temperature 80-90˚C, after which they were pealed to remove the coat and then milled into paste with an electronic blender ((Rico MG1810 750, Rico Appliances Pvt. Ltd, India). The resulting paste was stored in stainless steel container until when needed.

Preparation of meat samples

The meat samples were processed according to the procedure described by (13). They were trimmed of superficial fat and connective tissues and then cut across the muscle fibre axis into thin slices of about 2-3 mm thick. The fresh meat slices were weighed and laid out in a preheated oven set at 72 - 74˚C for 90 minutes to precook and partially dry them. The meat slices were turned over every 15 minutes to allow for even drying and to prevent them from getting stuck to the oven rack surfaces. This is the first stage of drying which lasted for 90 minutes. After this, the cooked meat samples were weighed and stored in stainless steel containers until further processing.

Preparation of the slurry

While the meat was cooking or drying, the kilishi slurry was made by blending in a mortar with pestle, the following ingredients; groundnut paste (50g), onion (6g), powdered garlic (6g), powdered ginger (6g), powdered curry (6g) ground red chilli pepper (3g), ground sweet pepper (3g), African nutmeg (6g) 2 seasoning cubes (Knorr), granulated sugar (6g) and kilishi colorant (6g), table salt (3g) These were blended with water until a uniform slurry was formed. The slurry was within 2 hours of production to minimize spoilage and possible development of rancid flavour.

Production of oven dried kilishi made from beef, chicken and pork

This was done according to the procedure described by (13) with little modification. The slurry was divided equally into three stainless steel containers. The partially dried beef, chicken and pork samples were infused into the slurries in different containers and left for 1 hour. After this, they were carefully spread out in the oven set at 63-65 °C for about 2.0 – 2.5 hours. The meat samples were turned over every 15 minutes to allow for even drying and to prevent them from getting stuck to the oven rack surfaces. The samples were judged sufficiently dry when they became crispy to touch and brownish in colour. They were transferred to stainless steel trays to cool to ambient temperature (28 ± 2˚C), and then packed in airtight plastic containers and stored for 24 weeks in a typical kitchen shelf at ambient conditions until further analysis. The procedure was replicated thrice and subjected to proximate and microbial analysis after 1 and 24 weeks of storage.

Proximate analysis of kilishi

The proximate composition of the kilishi samples were analysed according to the standard methods of (14)), Moisture content was determined by drying 5g of kilishi sample in an oven at temperature 105 °C to a constant weight. Crude protein of the kilishi samples was determined by Kjeldahl methods while Ether extract was obtained by Soxhlet extraction method using petroleum ether. Ash content of Kilishi was obtained by igniting 1g of kilishi samples in a Muffle furnace at 500 °C for 5 - 6 hours until ashes were produced.

Microbial counts

1g of finely ground kilishi samples were added to 9ml of sterile distilled water and homogenized with a stirrer. This was used to inoculate a nutrient agar media. Isolation of microorganisms was done using pour plate method following the procedures described by (15)

Experimental design and Statistical analysis

The data generated in this experiment were subjected to analysis of variance (ANOVA) in 3 x 2 factorial arrangement. The factors are meat types (beef, pork and chicken) and period of storage (1 and 24 weeks). Significantly different means were separated the multiple range test. SPSS software was used for the analysis.

Results and Discussion

Proximate composition

Significant effects of the meat types on the proximate composition of oven dried kilishi samples as shown in Table 1 was observed for all the parameters evaluated. Beef kilishi samples had significantly higher ($p<0.05$) crude protein content compared to other meat types. Chicken kilishi had higher crude fat and total ash while the pork kilishi was higher in nitrogen free extract. This could be due to the variation in the nutritional composition of the meats. This

agrees with (16) that variations in physicochemical parameters of various meat products depend on the type of meat and production process to lead to the loss of some soluble proteins. Similarly significant effect ($p<0.05$) of the storage period on the proximate composition of the kilishi produced from the meat types as shown in Table 2 was found in all the parameters evaluated except the moisture contents from 1st week to 24th weeks of storage.. As the kilishi samples were stored The ash and nitrogen free extract contents increased while crude protein and fat contents of the kilishi samples decreased from the 1st to 24th week of storage this could be due to the lipid oxidation process that undergone during storage. This agrees with (17) that reported that lipid oxidation causes loss of nutritional and sensory values with the formation of potentially toxic compounds that compromise meat quality.

Significant interaction effect between meat types and storage period as shown in Table 3 was also observed. Reduction in moisture content of beef and chicken kilishi samples were found but not in pork kilishi samples from 1st to 24th weeks. Similarly, crude protein content of chicken and pork kilishi reduced from 1st to 24th weeks of storage. However, total ash and nitrogen free extract of the kilishi increased across the samples. At 1st week of storage highest moisture and nitrogen free extract content were obtained in beef kilishi, chicken kilishi had the highest fat content while pork kilishi had highest crude protein and ash content. However, at 24th weeks of storage highest moisture and nitrogen free extract content were found in pork kilishi while beef kilishi had highest crude protein and fat content and highest ash content were obtained in chicken kilishi.

Increase in moisture content was observed in beef and chicken kilishi though they have the same moisture content however, use of pork in the production of kilishi caused a decrease in moisture content compared to other samples (Table 1). As the kilishi samples were stored moisture content decreased within the period of storage (Table 2). At 1st week of storage, beef kilishi had the highest moisture content while lowest moisture content was found in pork kilishi. However, at 24th week of storage, moisture content of pork kilishi increased while that of beef and chicken kilishi decreased. (Table 3). The moisture content of beef kilishi in this study was similar to the 12.8±0.51 - 13.7±0.47% reported by (18) and 10.02 – 12.02% reported by (7) on moisture content of kilishi produced from beef. However, the range values were higher than 9.87% reported by (23) and 6.92% reported by (24). The range observed in pork kilishi is close to the 7.63% reported by (21) and 9.92% reported by (13) on kilishi produced from pork. According to (22), drying of lean meat to 20% moisture inhibits most bacteria, yeasts and molds while a level of 15% moisture inhibits some species of fungi. Therefore, the low moisture content observed in this study showed that the products were sufficiently dried to limit microbial growth to tolerable minimum levels. This could be due to the step wise drying implored in the kilishi production,

Beef kilishi had the highest crude protein content compared to other treatments (Table 1). A reduction in crude protein content of the kilishi samples% was observed as they were stored from 1st to 24th week (Table 2). This decrease in the crude protein content was however not observed in beef kilishi where instead an increase in crude protein was observed. The highest crude protein was observed in pork kilishi while chicken kilishi had the lowest crude protein content at 1st week of storage. However, at 24th weeks of storage, crude

protein of beef kilishi increased while that of chicken and pork decreased (Table 3). The results of crude protein content obtained in this study from different meats at 1st to 24th week of storage were higher than 53.41 – 64.53% reported by (21), 51.62 – 55.84% reported by (7) on kilishi made from beef but similar to 61.72% reported by (21) on kilishi made from pork and higher than 22% reported as the average value of protein in meat (24). (24) reported that reasons for differences in essential amino acids proportions are due to breed. The variations in crude protein content of kilishi could be attributed to differences in essential amino acids in the meat types.

As shown in Table 1, the highest fat content was found in chicken kilishi compared to other treatments. As the kilishi samples were stored from 1st to 24th weeks, reduction in fat content across the samples were found (Table 2). From the interaction effect (Table 3), the meat types reacted differently with respect to their fat contents during storage. The fat content of chicken and pork kilishi decreased while no significant change was made among beef kilishi. The fat content of kilishi samples in this study were lower than 17.91- 18.31% reported by (12), 25.36±1.35% reported by (18) and 17.34 – 19.20% reported by (7) on kilishi made from beef. But similar to 10.11 – 10.57% reported by (21) and 8.35 – 10.7% reported by (25). The variations in fat content among the treatments could be attributed to the differences in fatty acid composition of fatty tissues of the meat samples. (24), reported significant differences in fatty acid composition of fatty tissues in different locations in poultry and other animals. Higher fat content found in chicken sample compared to other treatments could enhanced the flavour and juiciness of the sample.

Ash content was highest among chicken kilishi samples while beef kilishi samples were the lowest (Table 1). After 24th weeks of storage ash content of the kilishi samples increased (Table 2) and meat type related difference were also observed during storage (Table 3). Pork kilishi had the highest ash content while beef kilishi had the lowest at 1st week of storage. However at24th weeks of storage, highest ash content was found in chicken kilishi compared to other treatments (Table 3). The ash content observed in this study are similar to 5.71% reported by (24), 6.72±0.13 reported by (20) but lower than 9.55% reported by (21) and 9.6% reported by (8). The high ash content observed in chicken and pork kilishi samples could be attributed to their muscle tissues used. (27) had stated that the ash content of any processed meat would be the ash content of the muscle tissue in addition to that of ingredients used, and (24) reported that mineral composition of meat is dependent on animal breed, feeding type, genetics of animal and post mortem handling, This implies that high value of minerals can be achieved in kilishi if pork and chicken are used in the production.

Pork kilishi samples had the highest nitrogen free extract compared to other treatments (Table 1). After 24 weeks of storage, nitrogen free extract content of beef kilishi decreased while that of chicken and pork increased (Table 3). The nitrogen free extract contents obtained in this study are higher than 13.73 ± 1.83 reported by (28) on oven dried kilishi made from chicken, 13.16 – 18.90% reported by (29) , 14.8% in kilishi made from groundnut flour reported by (30) and 13.80 ± 0.57- 16.46 ± 0.35 reported by (12) . But similar to 18.9% obtained reported by (30) in Tunkusa kilishi. The highest nitrogen free extract found in beef kilishi could be that the sample absorbed higher amount of the slurry than other

treatments. The significant nitrogen free extract contents of the products in this study could have been contributed by the ingredients in the slurry since they are of plant origin which is high in common sugars (29).

Table 1: Mean proximate composition of oven dried kilishi made from beef, pork and chicken

Parameters %	Beef kilishi	Chicken kilishi	Pork kilishi	SEM
Moisture	13.89^{b}	13.89^{b}	11.14^{a}	1.15
Crude protein	69.32^{c}	62.56^{a}	63.11^{b}	0.1
Crude fat	6.29^{a}	8.68^{b}	8.25^{b}	0.13
Total Ash	5.28^{a}	7.45^{c}	6.40^{b}	0.04
Nitrogen free extract	19.12^{a}	21.32^{b}	22.25^{c}	0.20

^{a,b,c} Means within a row with different superscripts are significantly different ($p < 0.05$)

Table 2: Effect of period of storage on proximate composition of oven dried kilishi made from beef, pork and chicken

Parameters %	1st WEEK	24Th Week	SEM
Moisture	13.03	12.91	0.12
Crude protein	68.04	61.95	0.08
Fat	10.08	5.39	0.11
Total Ash	5.43	7.31	0.03
NFE	16.45	25.35	0.16

^{a,b,c} Means within a row with different superscripts are significantly different ($p < 0.05$)

Table 3: Effects of meat types (beef, chicken and pork) and period of storage interaction on proximate composition of the oven dried kilishi (%)

Meat type	Beef		Chicken		Pork		
Period of storage (week)	1	24	1	24	1	24	SEM
Moisture	17.50^{d}	10.29^{b}	14.50^{d}	13.27^{bc}	7.10^{a}	15.17^{cd}	0.20
Crude protein	68.83^{b}	69.81^{b}	65.80^{ab}	59.32^{a}	69.50^{b}	56.71^{a}	0.14
Fat	6.21^{ab}	6.36^{b}	12.28^{c}	5.07^{a}	11.75^{bc}	4.74^{a}	0.18
Total Ash	4.61^{a}	5.94^{ab}	5.71^{ab}	9.18^{c}	5.96^{ab}	6.82^{b}	0.06
Nitrogen free extract	20.34^{ab}	17.89^{ab}	16.21^{a}	26.43^{bc}	12.78^{a}	31.72^{c}	0.28

^{,b,c} Means within a row with different superscripts are significantly different ($p < 0.05$)

Microbial counts of oven dried kilishi like jerkies made from different meat types

Microbial count of oven dried kilishi produced from different meats (beef, chicken and pork) is presented in Table 4. The meat types had significant effect on the growth of microorganisms on the kilishi samples. Bacteria such as *Salmonella*, *Coliforms*, *Staphylococcus* and *Fungi* were isolated from the samples. Chicken kilishi samples had the highest total bacteria count, total viable bacterial counts, *fungi*, *Salmonella*, *E. coli*, *Staphylococcus* and total coliform. Significant effect of period of storage on microbial counts were also found ($p<0.05$) as shown in Table 5. Microbial counts of the kilishi samples increased from 1st to 24th

weeks of storage though meat type specific effect were also seen (Table 6). At 1st week of storage, pork kilishi had the lowest count of all the microbes isolated while the beef kilishi had the highest count of microbes isolated. However, at 24th week of storage, chicken kilishi had the highest count of fungi, salmonella, E. coli and staphylococcus while pork kilishi had the highest total coliform count isolated across the treatments (Table 6). The highest total plate count was found in beef kilishi at 1st week of storage. However, at 24th week of storage, chicken kilishi samples had the highest total plate count. The highest total viable bacteria count was found in chicken kilishi samples at both 1st and 24th weeks of storage (Table 6). Pork kilishi samples had the lowest total viable bacteria count at 1st week which increased at 24th weeks of storage. The total viable count obtained at 1st week of storage of this study was higher than the total aerobic plate counts range of 1.37 x103 to 1.72 x 103 cfu/g on day one and lower than 1.20 x 106 – 1.90 x 106 cfu/g on 150 days of storage reported by (7) and 1.2x105 – 7.6x105 reported by(31) and 2.1 x 102 cfu/g reported by (32) as minimum growth of bacteria on kilishi from companies and lower than 4.32 x 103 cfu/ml bacterial growths on fresh kilishi samples from the locally processed vendors in Port Harcourt, Nigeria (32). According to (20), the acceptable level of microbial load of ready to eat food products fall within a range of 5.4 - 8.0 log 10 cfu/g whereas the commission on microbiological specifications for foods (33) recommended a range limit between 2.5 x 105 to 1.0 x108 cfu/g for consumable meat products. Therefore, since the total viable count\ of the treatments obtained in this study falls within the acceptable range, it shows that the products are safe for consumption but pork kilishi samples are generally judged safer since it has lower microbial loads when compared to other treatments. This implies that good quality of kilishi that is safe for consumption can be obtained using all the three meat types. Since relatively higher total plate count and total viable count were recorded in chicken kilishi samples, they are likely to less shelf stable than beef and pork kilishi. A concentration of approximately 108 CFU/cm2 is regarded as a spoilage level for meat displayed or stored aerobically (34). Since these samples were all oven dried, the source of contamination of these kilishi samples especially chicken kilishi would be largely exogenous via handling, contaminated by hands, surfaces or utensils that were used during production and hence values reported here would better reflect the kilishi samples' capacity to support microbial growth under storage conditions described in the study. (35) reported that Salmonella could be transferred to cooked meat through hands, surfaces or utensils.

Table 4: Mean microbial counts of oven dried kilishi from beef, chicken and pork

Parameters cfu/g	Beef kilishi	Chicken kilishi	Pork kilishi	SEM
Total plate count	$3.55x10^{5a}$	$3.40x10^{8b}$	$3.29x10^{5a}$	$1.62x10^{6}$
Total viable bacteria count	1.62×10^{4a}	2.43×10^{4c}	1.73×10^{4b}	246.70
Fungi	4.28×10^{3a}	$1.72x10^{5b}$	4.06×10^{3a}	673.85
Salmonella	1.76×10^{2b}	1.77×10^{2b}	1.39×10^{2a}	1.74
Ecoli	1.23×10^{2b}	1.42×10^{2c}	1.03×10^{2a}	1.65
Staphylococcus	0.79×10^{2b}	1.29×10^{2c}	0.59×10^{2a}	1.68
Total coliform	0.85×10^{2a}	0.93×10^{2b}	0.88×10^{2c}	1.94

[abc]Means with different superscript along the same rows show significant different at ($p<0.05$),

Table 5: Mean microbial counts of the oven dried kilishi after 1 and 24 weeks of storage

Parameters cfu/g	1st week	24th week	SEM
Total plate count	$2.88x10^4$	$2.27x10^8$	$1.32x10^4$
Total viable bacteria count	$2.24x10^3$	$3.63x10^4$	201.43
Fungi	$0.91x10^2$	$1.21x10^5$	550.20
Salmonella	$0.94x10^2$	$2.33x10^2$	1.42
E. coli	$0.89x10^2$	$1.56x10^2$	1.35
Staphylococcus	$0.47x10^2$	$1.31x10^2$	1.37
Total coliform count	$0.46x10^2$	$1.38x10^2$	1.58

Table 6: Effect of meat types and period of storage interaction on microbial counts of oven dried kilishi

Meat type	Beef		Chicken		Pork		
Period of storage	1	24	1	24	1	24	SEM
Total plate count	$4.28x10^{4a}$	$6.67x10^{5b}$	$3.99x10^{4a}$	$6.80x10^{8c}$	$3.71 x10^{4a}$	$6.54x10^{5b}$	$2.29x10^2$
Total viable bacteria count	$2.60x10^{3b}$	$2.96x10^{3c}$	$2.6 x10^{3b}$	$4.60 x10^{4d}$	$1.48 x10^{3a}$	$3.31 x10^{4c}$	348.89
Fungi	$1.15x10^{2a}$	$8.46 x10^{3b}$	$8.7 x10^{a}$	$3.45x10^{5c}$	$7.1 x10^{a}$	$8.05 x10^{3b}$	9.53
Salmo	$1.32x10^{2b}$	$2.19x10^{2bc}$	$1.06 x10^{2ab}$	$2.49 x10^{2c}$	$4.5 x10^{2a}$	$2.33 x10^{2c}$	24.7
Ecoli	$1.08x10^{2ab}$	$1.38x10^{2bc}$	$1.00 x10^{2ab}$	$1.85 x10^{2c}$	$6.0x10^{a}$	$1.45x10^{2bc}$	23.4
Staph	$6.1x10^{ab}$	$9.7x10^{b}$	$7.1x10^{ab}$	$1.8x10^{c}$	$9.3 x10^{a}$	$1.09 x10^{2b}$	23.7
Total coliform count	$2.9x10^{a}$	$1.20x10^{2abc}$	$5.9 x10^{ab}$	$1.31 x10^{2bc}$	$5.0x10^{ab}$	$1.62x10^{2c}$	27.3

Conclusion and Applications

1. There were significant effects of meat types, storage duration and interaction between meat types and storage on proximate compositions of kilishi samples.
2. Microbial load of all kilishi samples increased increased with storage from 1st to 24th week of storage.
3. Oven dried kilishi produced from pork had the lowest microbial load values hence more likely to store better under ambient shelf conditions; while oven dried chicken kilishi had higher microbial loads and so might be more prone to microbial spoilage with reduced shelf life and organoleptic quality.
4. It is therefore recommended that pork and chicken meat (cautiously) can be used in the production of safe and wholesome kilishi, and more research work should be done to develop appropriate storage mechanisms in order to minimize adverse changes in composition and microbiology of kilishi samples.

References

1. Ryoba, R.N., Mulikambele, V.R., Mtenga, L.A. and 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*, 25.

http://wwwIrrd.org/Irrd25/1/ryob25010.htm

2. Dzimba, F. E. J. M., Faria, J. A. F. and Walter, E. H. M. (2007) Testing the sensory acceptability of biltong formulated with different spices. *Africa Journal of Agriculture and Research*, 2: 574 - 577.
3. Rahman, M. S., Salman, Z., Kadim, I. T., Mothershaw, A., Al-Tiziqi, M. H., Guizani, N., Mahgoub, O. and Ali, A. (2005). Microbial and physic-chemical characteristics of dried meat processed by different methods. *International Journal of Food Engineering*, 1-14.
4. Lee, S. J. and Park, G. S. (2004) The quality characteristics of beef jerky prepared with various spices. Korean *Journal of Food and Cookery Science*, 20: 489 - 497.
5. Biscola, V., Todorov, S. D., Capuano, V. S. C., Abriouel, H., Gálvez, A. and Franco, B. D. G. M. (2013) Isolation and characterizaion of a nisin-like bacteriocin produced by lacto- coccus lactis strain isolated from charqui, a Brazillian fermented, salted and dried meat product. *Meat Science*, 93: 607- 613.
6. Thomas, P., Yanis, C., Annesopie, P., Sunita, J. S. and Antoine, C. (2014). Physicochemical and microbiological characteristics of biltomg, a traditional salted dried meat of South Africa. *Meat Science*, 96, 1313-1317.
7. Iheagwara M.C.1 and 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): 01-09.
8. Igene, J.O., Farouk, M.M. and Akanbi, C.T. (1990). Preliminary studies on the traditional processing of Kilishi. *Journal of Science, Food and Agriculture*, 50: 89-98.
9. 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.
10. Muhammad, B.F. and Muhammad, A.M. (2007). Effect of packaging material and storage period on microbial load and organoleptic properties of Kilishi. Paper presented at the 12th Annual conference of the ASAN, Ile-ife, Osun State Nigerian, 12th -15th September 2007.
11. Nebenebor, C.A., Igene, J.O., Maigoge. S.P. and Collision, E.E.C. (1990). Microbial quality of kilishi meat product. *Journal of Animal Production Research*, 10: 91-1 07.
12. Igwe, E.J., Abdulahi, N., Abusalam, N., Dandago, M.A. and 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.
13. Ogunsola, O.O. and Omojola, A.B. (2008). Qualitative evaluation of kilishi prepared from beef and pork. *African Journal of Biotechnology*. 7(11): 1753-1758.
14. AOAC, (1996). Official Method of Chemical Analysis, (16th ed). Association of Official Analytical Chemists, Washington D.C.
15. 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.

16. Champomier-Verge`s, M.C. and Zagorec, M. (2015). *Spoilage microorganisms: risks and control*. In: Toldra, F. (Ed.), Handbook of Fermented Meat and Poultry (2nd ed.). John Wiley & Sons, Ltd., pp. 385 - 388.
17. Cortinas, L., Barroeta, A., Villaverde, C., Galobart, J., Guardiola, F. and Baucells, M. D. (2005). Influence of the dietary polyunsaturation level on chicken meat quality: Lipid oxidation. *Poultry Science*, 84(1), 48-55.
18. Daminabo, V., Isu N. R. and Agarry O. O. (2013). Antibiotic resistance profile of Enterococcal isolated from dried beef crackers (kilishi). *Sky Journal of Microbiology Research*, 1(5): 35 – 39.
19. Apata, E.S., Kuku1, I.A., Apata, O.C. and Adeyemi, K.O. (2013). Effects of different solar drying methods on quality attributes of dried meat product (Kilishi). *Journal of Food Research*, 2 (1): 80-86.
20. Jones, M.J., Tanya, V.N., Mbofung, C.M.F., Fonken, D.N. and 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.
21. Iheagwara, M.C., Chibuzo, I.H., Ibeabuchi, J.C. and Nzuruike, N.G. (2019). Physicochemical and organoleptic characteristics of kilishi as affected by meat types. *Annals Food Science and Technology*, 20: 553 – 562.
22. Ingram, M. and Smionsen, B. (1980). Meat and Meat Products. In microbial ecology of food, 2: 333.
23. Isah, O.A. and Okubanjo, A.O. (2012). Effect of various additives on proximate composition and acceptability of Kilishi made from semitendinosus muscle of white Fulani cattle. *Pacific Journal of Science and Technology*, 13(1): 506-511.
24. Ahmad, R. S., Imran, A., and Hussain, M. B. (2018). Nutritional composition of meat. In *Meat Science and Nutrition*. InTech. https://doi.org/10.5772/intechopen.77045
25. Inusa, S.K. and Said, I. S. (2017). Evaluation of the chemical and microbiological properties of sold in Kano metropolis. *Journal of Dry land Agriculture*, 3(1): 59 - 69.
26. Chukwu, O. and Imodiboh, L. (2009). Influence of storage conditions on shelf life of dried beef products (kilishi). *World Journal of Agricultural Sciences*, 5(1): 34-39.
27. Elizabeth B (1995). Ingredients in processed meat products paper presentation. Department of Animal Science and Industry Kansas state University, USA.
28. Aladi, N.O., Iyiola V.O., Onwudufor E.O. and Okeudo N.J. (2022). Production and evaluation of kilishi like jerky from chicken. *Proceedings of 27th Annual Conference of ASAN-NIAS, Bauchi, October 23 – 27th 2022. Pg* 259 – 262
29. Olusola, O.O., Okubanjo, A.O. and 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.

30. Mgbemere, V.N., Akpapunam, M.A. and 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.
31. Ogbonnaya, C. & Imodiboh, L.I. (2009) Influence of storage conditions on shelf-life of dried beef product (Kilishi). *World Journal of Agricultural sciences*, 5: 34-39.
32. Okonko, I. O., Odu, N. N. and Igboh. I. E. (2013). Microbiological analysis of kilishi sold in Port Harcourt, Nigeria. *New York Science Journal* 6, no. 7: 37-43.
33. ICMSF, (1996). International Commission on Microbiological Specifications for Food Microorganisms in Foods 5: Microbiological Specifications of Pathogens. p.89
34. Faustman, C., Sun, Q., Mancini, R. and Suman, S. P. (2010). Myoglobin and lipid oxidation interactions: Mechanistic bases and control. *Meat science*, *86*(1), 86-94.
35. Jay, M.J. (2000). *Modern Food Microbiology*. (6th ed). Aspen Publishers Inc., Gaithersburg, Maryland, 60-89.