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EFFECTS OF PROCESSING METHODS ON QUALITY CHARACTERISTICS OF KILISHI JERKIES

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ABSTRACT

The effects of processing methods (sun drying and oven drying) on quality characteristics of kilishi like jerkies were compared. The beef samples were processed into kilishi by sun drying or oven drying and then analysed for proximate composition, microbiology and sensory qualities after 1st and 12th weeks of storage. The data generated except sensory scores were analysed in a 2x2 factorial arrangement using a completely randomized design (CRD). The results of proximate analysis showed significant effects of the processing methods and period of storage in all the parameters analysed. Although microorganisms such as *Fungi, Salmonella, E-coli, Staphylococcus* and *total coliform* were isolated from the treatments, kilishi that was produced through sun drying had higher values of isolated microbes than counterparts produced by oven drying. Sundried kilishi had higher scores in all the sensory parameters analysed than the oven dried kilishi. The study indicated that production of safer and more wholesome kilishi snacks can be achieved through the use of oven drying, nonetheless, the sensory quality characteristics of sundried kilishi had higher scores and were preferred to the oven dried kilishi. Therefore, recommendation is made to increase the ingredient composition of the oven dried kilishi in order to meet the sensory qualities required by the consumers.

Keywords: Kilishi; oven dried; sun dried; proximate composition; microbial count

INTRODUCTION

Meat is the most common and most valued food of animal origin all over the world due to its outstanding sensory quality, excellent nutritional values and varied culinary properties. Since 1960, there has been a significant increase in global meat production attributable to increase in population and affluence in many countries (Speedy, 2003). According to Delgado *et al*. (1998), consumer demand driven increase in the production of meat and meat products is expected in the developing countries between 2010 and 2050. Currently, the global meat production is over 340 million tons each year and per caput meat consumption per annum in developing countries has grown from a modest 10 kg in the 1960s to 26 kg by 2000 and is expected to reach 37 kg by the year 2030 (FAO, 2006). Despite these increases, meat is still largely consumed after minimal processing in the kitchen for value addition.

Fresh meat has a very short shelf life of 24 hours or less at ambient temperatures of 20 – 30 °C (Lambert *et al*., 1991), and so will require careful handling and preservation strategies to prevent spoilage by multiplication of microorganisms (Lawrie, 1991). This often requires low temperature storage which is largely dependent on a steady availability of electricity. Hence the present-day techniques of meat preservation are sophisticated, requiring stable power supply which is often lacking in many developing countries of the sub-Saharan Africa.

Theoretical framework

For most developing countries, simple technologies such as sun drying is largely employed because they are more affordable and are better suited to the culture and food habits of the indigenous peoples (Chua & Chou, 2003). Drying is one of the oldest methods used to prolong the shelf-life of foods. It reduces the moisture content of products to very low levels thereby limiting the growth and proliferation of spoilage microbes (Ryoba *et al*., 2013). Drying is one of the major processing techniques in the production of many traditionally processed ready-to-eat meat products in Nigeria, such as balangu (roasted meat), kilishi, dan-bu-nama, tsire, jirga, ndako, banda, suya, etc (Chua & Chou, 2003). These local food products are highly cherished due to their unique flavours (Biscola *et al*., 2013) and cultural significance (Thomas *et al*., 2014). In Nigeria and some other countries in sub-Saharan Africa, kilishi is increasingly gaining widespread acceptance and importance in recent times (Okafor, 2010).

Kilishi is a traditional sun-dried jerky made from beef, mutton or chevon. It is a rich nourishing snack with a supplemental plant protein that is formulated using hurdle technology (Iheagwara & Okonkwo. 2016). Beef is mostly used (Igene *et al*., 1990). It 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 (Igene, 1988). Kilishi production is mainly localized in the northern parts of Nigeria due to abundance of livestock and relatively dry weather. Its production is largely in the hands of traditional producers (Igene *et al*., 1990; Kibbon, 2006).

In recent times, an increasing attention is being paid to the effects of diet on human health and

well-being with an attendant, albeit unfounded bias against the safety of traditional methods and practices. Microbial level in kilishi is becoming an issue of great concern for many consumers (Olusola *et al*., 2017). (The ambient conditions in the predominantly rain forest belt of southern Nigeria do not allow for proper drying of the product and thus reducing the shelf life and increasing microbial contamination. There is need therefore to explore alternative methods for drying kilishi other than sun drying. These options are 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 to the industry. The objective of this study is to compare the proximate composition, microbial count and sensory quality characteristics of kilishi produced through sun drying and oven drying methods.

MATERIALS AND METHODS

Production of sundried kilishi

Lean cuts from the round of freshly slaughtered White Fulani cattle were procured from meat vendors in Wukari, Taraba State and stored at 10 °C under very hygienic condition for 6 hours before use. Samples were processed into kilishi following the procedures described by Ogunsola & Omojola (2008). The meat cuts were trimmed free of superficial fats and connective tissues and then sliced along the fibre axis into thin sheets of 2- 3 mm thickness. The slices were spread on a raised concrete platform lined with raffia mats and placed under the sun for 2-3 days to dry. The meat slices were turned over every hour to allow for even drying and to prevent meat from getting stuck to the drying surface. Kilishi slurry was produced according to the procedure described by Ogunsola & Omojola (2008).

Preparation of kilishi slurry

Groundnut seeds were roasted for 10 min at 80 – 90 °C and cooled. The testas were peeled off, and the seeds were cleaned and milled into a paste. The milled paste was kneaded in a round bowl to express the oil. The resultant paste was wrapped in four layered muslin cloth and pressed under screw jack to expel as much oil as possible. The residue after oil extraction was placed in a wooden mortar and then blended with water and other ingredients such as ginger, black pepper, red pepper, garlic, onion, Africa nutmeg, curry, salt, sugar and knorr® Seasoning cubes into a moderately thick slurry. The composition of the slurry is shown in Table 1.

Production of sun-dried beef kilishi

The sundried meat slices were soaked in the slurry for 45 minutes and then spread out on the mat for final drying. This lasted for 6 – 10 hours, after which the infused meat slices were heated over burning firewood for 5 - 10 minutes to further dry the products, destroy the microorganisms and cook the product. The kilishi samples were then spread on a stainless-steel tray and covered with clean muslin cloth to cool to ambient temperatures before being packaged into airtight plastic containers until needed for further analysis.

Production of oven dried beef kilishi

Lean cuts, meat slices and kilishi slurry were prepared as previously described. The fresh meat slices were weighed and laid out in the pre heated oven set at 70 ˚C for 90 minutes to partially dry and cook the meat slices. The meat slices were turned over every 20 minutes to allow for even drying and to prevent them from getting stuck to the oven rack surfaces. After this, the precooked cooked meat samples were weighed and infused with the groundnut slurry and left for 60 minutes. After this, the infused samples were carefully spread out in the pre heated oven set at 65 ℃ for 120 min to dry. The meat slices were turned over every 20 min. The samples were judged sufficiently dry when they became crispy and brown in colour. After this, they were removed and kept on stainless steel tray and covered with 2 layers of muslin cloth to cool to ambient temperature, and then packed in airtight stainless-steel containers and stored in a typical kitchen shelf until needed for further analysis. This was replicated thrice and subjected to chemical, microbial and sensory quality characteristics.

Table 1: Ingredient composition of the kilishi slurry

Ingredient	Quantity (g)
Groundnut paste	50.00
Powdered garlic	6.00
Powdered ginger	6.00
Sweet pepper	3.00
Red pepper	3.00
African nutmeg	6.00
Onion	3.00
Powdered Curry	6.00
Seasoning cubes (Knorr)	2.00
Colourant (red)	6.00
Salt	3.00
Sugar	6.00
Total	100.00

Proximate analysis of kilishi

The proximate composition of the kilishi samples was determined according to the methods of AOAC (1996). Moisture content was determined by drying 5g of kilishi sample in an oven at temperature of 105±5°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

One gram of finely ground kilishi samples were added to 9 ml of sterile distilled water and homogenized. The resultant mixture was used to inoculate nutrient agar (Anteg. Diagnostic T^{m} UK) and incubated for 2 – 3 days at 20 – 30 °C and screened under an optical microscope (×400) for *Salmonella* and *Escherichia coli*. Plates containing Potato Dextrose Agar (Int. Diagnostic Group Plc) were also inoculated, inverted and incubated at 36 °C for four days in a Gallenkamp incubator for yeast and mould counts. Pour Plate Method was used following the methods described by Shamsuddeen (2009).

Sensory evaluation of the kilishi

Thirty samples each of the sundried and the oven dried kilishi were served randomly to a trained panel of 30 students drawn from the 500 level students of the Department of Animal Science and Technology, Federal University of technology, Owerri, Nigeria. Membership of the panel was voluntary while selection of panel members was based on interest, taste and flavour acuity and ability to understand the test procedures. Each student evaluated a sample from both treatment groups (sun dried and oven dried). Samples were evaluated for overall appearance, colour, tenderness, juiciness, flavour and hotness characteristics using the 9-point hedonic rating scale as described by Ranganna (2001). The sensory evaluation was carried out 1 week after production.

Experimental design and Data analysis

The experimental design for proximate composition and microbial content was completely randomised design in a 2x2 factorial arrangements while sensory quality parameters was the completely randomised design. The mean scores from the proximate composition and microbial analyses were subjected to analysis of variance, while means from sensory evaluation were analysed using the t test. Statistical computations were executed on the SPSS 20 versions software.

RESULTS AND DISCUSSION

Proximate composition

The effect of the processing methods and the period of storage on the proximate composition of kilishi samples are shown in Table 2. Significant interaction effect ($p < 0.05$) between the processing methods and the period of storage was observed in all the parameters analysed on the samples. As the samples were stored from 1 week to 12 weeks reduction in moisture content and nitrogen free extract and increase in crude protein, fat and ash were observed across the samples. At 1st week of storage, no interaction effect between processing method and period of storage was found on the samples. Although there was no significant difference ($p > 0.05$) found in moisture contents of both treatments, but the moisture content of sundried traditional kilishi was higher than oven dried kilishi. However moisture contents of both treatments increased after 12 weeks of storage with the sundried samples having a higher value than the oven dried. This suggests that kilishi samples must have absorbed moisture from the environs under the storage conditions used in this experiment and this water absorption was not affected by processing methods used. Kilishi is usually wrapped with paper and stored under ambient conditions inside loosely tied polyethene bags or kept on typical kitchen or household shelves. Its spicy nature is believed to naturally ward off insects and prevent microbial proliferation. According to Ogbonnaya & Imodiboh (2009), drying of lean meat to about 20% of moisture inhibits most bacteria, yeasts and moulds growth while a level of 15% moisture inhibits some species of fungi only. Hence, the high water absorption or adsorption potential observed in this study suggests that prolonged storage of kilishi under such ambience may encourage proliferation of deleterious microbes which may pose public health concerns. The moisture contents of kilishi after I week of storage obtained in this study are similar to 11.6 -12.10% reported by Mgbemere *et al*. (2011), 10.02 – 12.02% by Iheagwara & Okonkwo (2016) but lower than 12.8- 13.7 reported by Daminabo *et al*. (2013), 17.91 – 18.31% by Igwe *et al*. (2013) and Fakolade & Omojola (2008). The relatively low initial moisture contents observed in both sundried and oven dried kilishi samples in this study showed that they were sufficiently dried to hinder microbial growth. This could be attributed to the two stepwise drying in kilishi processing (Change *et al*., 1996; Rahman *et al*., 2005).

Significant effects ($p< 0.05$) of the processing methods and period of storage were found for the protein content of kilishi samples in this study, indicating that the changes in crude protein contents over the 12 weeks of storage period were directly related to the processing methods. As the samples were stored, reductions in crude protein of the samples were found within the period of storage. The mean crude protein contents of kilishi produced by oven drying was higher than one produced by sun drying both at 1st and 12th weeks of storage (Table 2), After 12 weeks of storage, the mean crude protein of the kilishi samples decreased across the treatments. The highest crude protein value was obtained in oven dried samples at 1st week of storage (68.17). The values of CP obtained in this study are higher than those reported by Daminabo *et al*. (2013) (60.60±0.11 - 60.90±0.6%); 61.82 – 65.12% by Alamuoye (2019); 61.30% by Iheagwara *et al*. (2019); 51.62 –

55.84% by Iheagwara & Okonkwo (2016) and 33.88 – 60.33% reported by Ogunsola & Omojola (2008). Generally, these authors agree that processing meat into kilishi increase the protein content of the final product relative to fresh or dried meat products (Ogunsola & Omojola, 2008; Okorie, 2018). Therefore, the high value of crude protein observed in oven dried kilishi could be attributed to method of processing (oven drying).

Reduction in the fat contents of the samples were observed as the interaction effect of the processing methods and period of storage was evaluated (Table 2). Similar trend was found as the samples were stored from 1 to 12 weeks. The mean fat content of the kilishi sample that was produced by sun drying was significantly ($p<0.05$) higher than the ones produced by oven drying (Table 2). Sun dried kilishi samples had higher fat contents than oven dried ones at 1st week though the later had more fat at 12th weeks of storage. Thus, indicating a strong interaction effect between processing method and storage period while the values obtained in this study were lower than the 8.35 – 10.07% reported by Inusa & Said (2017), 10.11 – 10.57% by Iheagwara *et al*. (2019) and 17.34 – 19.20% reported by Mgbemere *et al*. (2011). Therefore, kilishi produced by oven drying is likely to be preferred by some consumers for its lower fat content (Youl *et al*., 2012). Significant losses of fat in many meat cuts during broiling, grilling and pan frying without added fat have been reported by Grunert *et al*. (2004). Hence, the lower fat content obtained in kilishi sample produced by the oven drying method at 1st week of storage could be attributed to losses during cooking.

Generally, the kilishi samples produced by sun drying had ash significantly ($p<0.05$) higher than those produced by oven drying (Table 2). Reduction in the ash contents after 12 weeks of storage was observed (Table 2). Though the ash content of sundried samples was higher than those of oven dried samples at 1st week of storage, the values (4.60 vs 5.00) were similar after 12 weeks of storage. This implies that high value of ash content can be achieved in kilishi if it is produced by sun drying and stored for a very short period. Mineral leaching during cooking is likely to be responsible for the lowered fat and mineral content of kilishi produced by oven drying. Undesirable changes leading to decrease in the nutritional value, particularly of mineral and vitamin and changes in the composition of fatty acid have been reported by Rodriguez-Estrada *et al*. (1997). The ash content of sundried kilishi at 1st week of storage was higher than the range values of 6.75 – 9.5% reported by Jonathan *et al*. (2016), 9.55% by Iheagwara *et al*. (2019) and 6.72±0.13% reported by Jones *et al*. (2001).

The nitrogen free extract of kilishi samples produced by oven drying was significantly ($p<0.05$) higher than the one produced by sun drying Table 2. An increase in ash contents of the samples were observed as the samples were stored within the storage period. However, at 12th weeks of storage among the sundried and oven dried samples, this increase was not significant (16.92 and 15.49%). Heat induced changes in the carbohydrate contents of oven dried kilishi samples must have been responsible variability of nitrogen free extract during storage. Heat induced reactions between free amino acids and soluble sugars such as Maillard reaction occur particularly dry heat cooking of meat (Sun *et al*., 2022). Alongside the browning effects, Maillard reaction release a lot of intermediate volatile metabolites which impart specific flavours of cooked dry heat cooked meat products (Ojo *et al*., 2002; Davila *et al*., 2022). The release of these metabolites may have contributed largely to the variations in nitrogen free extract and fat content of sundried and oven dried kilishi samples. These nitrogen free extract values at 1st week in this study are lower than 13.73 ± 1.83 reported by Aladi *et al*. (2022), 13.16 – 18.90% by Olusola *et al*., 2017 and 13.80 ± 0.57- 16.46 ± 0.35 reported by Igwe *et al*. (2015), 18.9% obtained in Tunkusa Kilishi and 14.8% in groundnut flour Kilishi reported by Mgbemere *et al*. (2011). But at 12th weeks of storage the values obtained in this study are higher than some of the values reported by authors previously mentioned. The variations in the composition and quantity of ingredients used in these studies may have contributed the higher nitrogen free extract values at 12th weeks of storage since they are plant origin and which are high in common sugars (Olusola *et al*., 2017).

Table 2: Effects of processing method and period of storage on proximate composition of kilishi samples

Parameters	Sundried kilishi		Oven dried kilishi		SEM
Storage period	1 week	12 weeks	1 week	12 weeks	
Moisture	11.51^{a}	21.78^{c}	10.39^{a}	20.00^{b}	0.567
Crude Protein	65.63^{c}	51.95^{a}	68.17^{d}	54.51^{b}	0.259
Fat	8.29^{d}	4.75^{a}	6.11^{c}	5.05^{b}	0.053
Total Ash	10.08^{a}	4.60^{c}	6.19^{b}	5.00^{b}	0.052
NFE	4.49^{a}	16.92^{c}	9.14^{b}	15.49^{c}	0.657

abc=means with different superscript along the same rows show significant different at ($p<0.05$), SEM= Square error of mean; NFE – Nitrogen Free Extract

Microbial counts

Significant interaction effects were observed on the effect of processing methods and period of storage on microbial composition of kilishi samples (Table 3). Microbes such as *Fungi*, *Salmonella*, *Staphylococcus*, *E.coli* and *Total coliform count* were isolated from analysed samples. In all the parameters analysed, sundried kilishi had higher mean values of microbes isolated than oven dried kilishi both at 1st and 12th weeks of storage. As the samples were stored from 1st to 12th weeks microbial counts of the samples increased. No significant effect was found on total plate count, total viable bacteria count and total coliform count of sundried and oven dried kilishi at 1st week of storage. This implies that the processing methods and storage period implored in this study had no effects on these parameters of the samples but the environments. The higher mean value of total viable bacteria count (3.4613 and 3.36673 Log_{10}) obtained in kilishi samples at one week of storage was higher than the 1.37 $x10^3$ to 1.72 x 10^3 cfu/g on day one and lower than 1.90 x 10^6 – 1.20 x 10^6 cfu/g after 150 days of storage by Iheagwara & Okonkwo (2016) and the $1.2x10^5$ – $7.6x10^5$ (Ogbonnaya & Imodiboh, 2009), 2.1 x 10^2 cfu/g - 4.32 x 10^3 cfu/g bacterial found on fresh kilishi samples from the locally processed vendors in Port Harcourt, Nigeria reported by Okonko *et al*. (2013) The low bacterial counts observed in oven dried kilishi in this study suggests that good quality of kilishi that is safe for consumption can be obtained using oven drying method. The higher microbial load observed in kilishi that was produced by sun drying could be attributed to the contamination of the product by microorganism during production especially during sun drying. This agrees with Igwe *et al*. (2015) and Okonko *et al.* (2013) that reported that poor post-slaughter handling of meat, non-observance of good manufacturing practices during processing such as prolonged exposure to air, dust and flies during drying, the use of unhygienic equipment and utensil and poor personnel and environmental hygiene during processing are the major sources of contamination of kilishi

Table 3: Effect of processing methods and period of storage on microbial composition of kilishi samples (Log_{10} CFU)

Parameters	Sundried kilishi		Oven dried kilishi		
Storage period	1 week	12 weeks	1 week	12 weeks	SEM
TPC	4.7850[a]	12.9090[c]	4.5987[a]	6.7767[b]	0.19259
TVBC	3.4613[a]	10.1397[c]	3.3673[a]	6.4953[a]	0.19939
Fungi	2.1123[a]	12.7473[d]	2.7577[b]	6.3267[c]	0.02176
Salmonella	2.1710[b]	4.7840[d]	1.8570[a]	2.5987[c]	0.04101
Staphylococcus	2.0427[b]	4.5957[d]	1.8120[a]	2.1973[c]	0.02520
Escherichia Coli	2.1430[b]	4.5077[c]	1.8363[a]	2.2110[b]	0.04049
TCC	1.8760[a]	4.3617[c]	1.8770[a]	2.0487[a]	0.18919

[abc] Means with different superscripts along the same rows are significantly different ($p<0.001$), TPC= Total plate count; TVBC= Total viable bacterial count; TCC=Total coliform count

Sensory panel score

The sensory panel scores of sundried and oven dried kilishi are shown in Table 4. Significant difference was observed in all the parameters evaluated by the panellists. The hedonic rating of traditional sundried kilishi had the higher scores in overall appearance (7.00), colour (6.73), sample overall (7.27), flavour (7.53), tenderness (7.00), juiciness (6.93) and hotness (5.4) than oven dried kilishi. This could be attributed to higher fat contents of sundried kilishi samples. According to Winger & Hagyard (1994), juiciness is related to the fat content of the meat and it is considered to be a result of the stimulating effect of fat on salivary flow. Mottram (1998) reported that fats or fat-soluble precursors contribute to significantly to meat flavour. The higher value of red colour obtained in sundried kilishi (Table 1) must have led their superior overall appearance and colour preference scores by the panel. Most meat colour pigments (myoglobin, etc.) are denatured by heat and so oven drying is expected to affect colour and other visual scores of oven-dried kilishi samples. The appearance of a meat is an important factor that influences how consumers perceive the quality of meat (Faustman *et al*., 2010) and Becker (2002) also reported that preferences for meat seem to be strongly affected by colour or appearance, texture and to a lesser extent by changes in flavour.

Table 4: Panel sensory score of traditional sundried and oven dried kilishi

Parameters	Traditional kilishi	Oven dried kilishi	SEM
Overall appearance	7.00	5.33	0.44
Overall colour	6.73	5.27	0.45
Sample overall	7.27	5.73	0.55
Overall flavour	7.53	5.73	0.47
Tenderness	7.00	5.20	0.66
Juiciness	6.93	5.47	0.59
Hotness	5.4	4.6	0.73

NS= Not Significant, SEM= Square error of mean

CONCLUSION AND RECOMMENDATION

The results of this study indicate that slight variations were observed on proximate composition of sundried and oven dried kilishi made with beef. Kilishi samples produced by oven drying had superior proximate and microbiological quality characteristics to those produced by sun drying. However, the sensory quality characteristics of sundried kilishi were preferred by the sensory panellists due probably to their superior fat contents. The microbial counts of the kilishi samples after 12 weeks of storage suggest that it might not be safe to store them over prolonged period of time. Further studies are however recommended on the effect of non-meat ingredients, oven temperature and effect of storage conditions on the quality of oven dried kilishi.

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