EFFECT OF SALT TYPES ON OXIDATIVE STABILITY AND SENSORIAL PROPERTIES OF KILISHI

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ABSTRACT
The study was aimed at investigating the impact of salt types on cholesterol oxides, lipid oxidation, protein oxidation and sensorial quality of Kilishi. Kilishi was made from sundried slices of Semitendinosus muscles, and infusion mixture containing either 2.20% NaCl, T-1; 1.10% NaCl + 1.10% Monosodium glutamate (MSG), T-2; 1.10% KCl + 1.10 %MSG, T-3; 1.10% C6H5K3O7 + 1.10% MSG, T-4, or 2.20% MSG, T-5. T-1 Kilishi had greater Na content (p<0.05) compared to other treatments. Total cholesterol oxides and 25-hydroxycholesterol were higher in T-1 and T-2 compared with other treatments. Malondialdehyde and carbonyl contents and sensory properties did not differ among the treatments. The substitution of NaCl with KCl, MSG and C6H5K3O7 reduced sodium content and total cholesterol oxides without compromising the sensorial quality of Kilishi.
Keywords: cholesterol oxides; carbonyl; malondialdehyde; monosodium glutamate; sodium

INTRODUCTION

Salt is the most commonly used functional ingredient in processed meat product, and it is used primarily for flavor but also has secondary functions including inhibiting microbial growth, extending shelf-life and increasing protein hydration (Gaudette, and Pietrasik, 2017). Globally, processed foods account for about 70% of salt consumption, with meat products providing 20% of the total (Vidal *et al*., 2023). Consuming too much salt has been linked to a number of health problems, such as high blood pressure and cardiovascular disorders (Cappuccio *et al*., 2013). Thus, it is crucial to lower the salt content of meat products in order to encourage healthier eating practices. One popular strategy is to substitute less-sodium-containing components with conventional sodium-containing ones, such as salt and sodium-based additives (Wang *et al*., 2023). However, salt substitutes can have a bitter aftertaste, which might affect the overall flavor of the meat product and lead to consumer dissatisfaction (Xiao-Hui *et al*., 2023). Further, salt substitutes might have a shorter shelf life compared to NaCl due to potential issues with solubility and stability (Vidal *et al*., 2021). Thus, incorporating ingredients exhibiting sweetening, antioxidant and antimicrobial properties may alleviate the shortcomings associated with the use of salt substitutes in meat products (Gaudette, and Pietrasik, 2017). Monosodium glutamate is commonly used as a flavor enhancer in foods as it adds umami flavor and enhance food palatability. Nonetheless, there is limited investigation on its potential in reducing sodium content in beef jerky. Meat products are rich in cholesterol, which is readily amenable to oxidation thereby generating various cholesterol oxidation products (COPs) during processing and storage (Min *et al*., 2016). Ingestion of COPs could exert harmful effects on human health (Kulig *et al*., 2016; Deng *et al*., 2023). NaCl plays a crucial role in oxidative deteriorations, which may affect COP formation in meat products (Kang *et al*., 2008; Mariutti, and Bragagnolo, 2017). However, the role of salt types in COP formation in meat products has been scarcely investigated. Kilishi is a common traditional meat snack in Nigeria. However, despite being a well-known delicacy, Kilishi can often be high in sodium due to the salt and spice mixtures used in its preparation. Thus, reducing sodium content in Kilishi can accommodate consumer preferences for healthier choices, and enhance overall customer satisfaction. The objective of this study was to assess the influence of salt types on oxidative stability and sensorial quality of Kilishi.

Materials and methods

Preparation of meat, infusion mixture and Kilishi

Four batches of beef S*emitendinosus* (4.3 ± 0.4 kg per batch) were obtained from a local meat shop at 24 h postmortem. Each batch constitutes a replicate and was separately processed into *Kilishi*. *Kilishi* was prepared in accordance to the techniques outlined by Igene, and Farouk (1990). The meat was sliced into 90–100 cm length and 0.10–0.20 cm thick pieces. Meat slices were spread on raised beds covered with dried sorghum stem mats and sun-dried for 9 h at 36.3 ± 2.4 ºC and 23 ± 2.5% relative humidity. Sundried meat slices were randomly marinated in infusion mixture containing either 2.20% NaCl, T-1; 1.10% NaCl + 1.10% Monosodium glutamate (MSG), T-2; 1.10% KCl + 1.10 %MSG, T-3; 1.10% $C_6H_5K_3O_7$ + 1.10% MSG, T-4, or 2.20% MSG, T-5 (Table 1) for 1 h. The ratio of raw meat slices to infusion mixture was 1:1. Following the first drying cycle, the ratio of sundried meat slices to infusion mixture was 1:4. Marinated meat slices were sun-dried for 6 h and roasted over a fire for 3 min. Sodium content was determined by AOAC (1990) procedure. Extraction and determination of cholesterol oxides were carried out as described by Mariutti *et al.* (2008). Carbonyl and malondialdehyde contents were assessed as described by Adeyemi (2021). Sensory analysis was performed following the protocol of AMSA (1995).

Table 1: Composition of infusion mixture for Kilishi production

Ingredients	T1	T2	T3	T4	T5
Groundnut cake	44.21	44.21	44.21	44.21	44.21
Fresh Red pepper (*Capsicum annuum*)	2.63	2.63	2.63	2.63	2.63
Ginger	3.68	3.68	3.68	3.68	3.68
Garlic	3.16	3.16	3.16	3.16	3.16
Fresh Scotch bonnet (*Capsicuum chinese*)	8.42	8.42	8.42	8.42	8.42
Clove	0.26	0.26	0.26	0.26	0.26
Nutmeg	0.26	0.26	0.26	0.26	0.26
Black pepper (*Piper guineaense*)	0.26	0.26	0.26	0.26	0.26
Onion	2.63	2.63	2.63	2.63	2.63
NaCl	2.20	1.10	0.00	1.10	0.00
KCl	0.00	0.00	1.10	0.00	0.00
$C_6H_5K_3O_7$	0.00	0.00	0.00	1.10	0.00
Monosodium glutamate	0.00	1.10	1.10	0.00	2.20
Thyme	0.05	0.05	0.05	0.05	0.05
Water	32.28	32.28	32.28	32.28	32.28

RESULTS AND DISCUSSION

The sodium content, indicators of oxidative spoilage, and sensory attributes of Kilishi treated with different salt types are presented in Table 2. The substitution of NaCl with KCl, $C_6H_5K_3O_7$ and MSG led to a significant reduction in sodium content in Kilishi. Kilishi treated with 2.20% NaCl had the highest Na content that was significantly different from those of other treatments. This was followed by the T-2 and T-5. The T-3 and T-4 had the least Na content. This result is noteworthy because it aligns with the current declining trend in Na consumption. This result is in line with those of Cittadini *et al*. (2020) who found that partially replacing NaCl with KCl, reduced the quantity of Na in dry-cured foal. Moreover, replacing NaCl with KCl, $CaCl_2$, and $MgCl_2$ reduced Na content in Pastimir, a Turkish beef jerky (Yalınkılıç *et al*., 2023). Processing conditions and meat product composition can influence the kind and amount of COPs (Min *et al*., 2016), whose consumption could be harmful to consumers' health (Kulig *et al*., 2016; Deng *et al*., 2023). Of the 8 COPs detected in this study, five were influenced by salt types. Kilishi samples containing 2.20 and 1.10% NaCl had greater 25-hydroxycholesterol and total COP content compared with other Kilishi samples. This was followed by Kilishi sample treated with 2.20% MSG. The lowest 25-hydroxycholesterol was recorded in Kilishi samples treated with KCl and $C_6H_5K_3O_7$. Moreover, the T-2 and T-3 presented higher concentration of 7-ketocholesterol and 7β-hydroxycholesterol respectively than other treatments while the T-4 presented greater concentration of cholesta-3,5-dien-7-one and 6-β-epoxide. The changes in the cholesterol oxides may reflect the prooxidant potential of the salt types. The reduction in NaCl content could be responsible for the reduction in total COP contents in T-3, T-4 and T-5. Salt ions can promote the oxidation of cholesterol by enhancing its mobility and availability for oxidative reactions (Mariutti, and Bragagnolo, 2017). Moreover, NaCl can drive the formation of cholesterol ester hydroperoxides, which can further decompose and generate COPs (Paniangvait *et al*., 1995). Similarly, increased NaCl concentration raises COP content in sun-dried Gulbi fish (Kang *et al*., 2008) and sun-dried shrimp (Hernández□Becerra *et al*., 2014). The carbonyl and malondialdehyde contents of Kilishi were not influenced by salt types. It is possible that some ingredients (such as garlic, ginger and pepper) present in the infusion mixture exert antioxidant effects, which masked the prooxidant effect of the different salt types. To ensure consistent quality, match consumer expectations, develop new products, ensure safety, and gain a competitive edge in the market, sensory analysis of meat products is crucial (AMSA, 1995). Salt types had no effect (p>0.05) on the sensorial attributes of Kilishi implying that the substitution of NaCl with KCl, MSG and $C_6H_5K_3O_7$ did not compromise the organoleptic properties of Kilishi.

Table 2. Sodium content, and oxidative stability, and sensory traits in Kilishi treated with different salt types

	Treatment[1]						
Items	T-1	T-2	T-3	T-4	T-5	SEM	P value
Na (mg/100g)	1567^a	987^b	456.2^d	448.2^d	745.6^c	32.51	<.0001
Cholesterol oxides (µg/100 g)							
19-hydroxy cholesterol	0.05	0.05	0.04	0.04	0.05	0.02	0.09
Choleststanetriol	nd	nd	nd	nd	nd		
25-hydroxycholesterol	992^a	972^a	55.10^c	50.45^c	533^b	15.45	<0.001
7-ketocholesterol	22.34^b	76.34^a	24.50^b	23.33^b	23.67^b	10.23	0.045
7α-hydroxycholesterol	0.40	0.40	0.50	0.04	0.50	0.01	0.087
7β-hydroxycholesterol	24.34^c	12.30^d	166.30^a	64.04^b	4.70^e	2.30	0.034
20α-hydroxycholesterol	nd	nd	nd	nd	nd		
cholesta-3,5-dien-7-one	20.23^b	25.67^b	28.76^b	115.2^a	20.00^b	5.67	0.021
6β-epoxide	23.0^c	20.34^c	48.67^b	76.24^a	1.20^d	3.40	0.033
Total COP	1035^a	1107^a	323^c	329^c	578^b	26.67	0.043
Malondialdehyde (mg MDA/kg)	0.34	0.39	0.36	0.32	0.36	0.05	0.120
Carbonyl mmol/kg	0.18	0.20	0.19	0.18	0.19	0.09	0.110
Sensory attributes							
Taste	6.23	6.00	6.13	5.66	6.10	0.37	0.122
Appearance	5.98	6.23	5.77	5.89	5.99	0.50	0.222
Flavor	6.12	6.12	5.50	6.00	5.89	0.55	0.145
Tenderness	6.45	5.78	5.89	6.14	6.00	0.46	0.423
Juiciness	5.78	6.03	6.00	6.38	6.10	0.55	0.089
Overall acceptability	6.00	5.89	6.12	6.34	6.12	0.67	0.102

[a, b, c,] means with different superscripts along the same row are significantly different ($P < 0.05$). [1]T-1=2.20% NaCl; T-2=1.10% NaCl + 1.10% MSG; T-3=1.10% KCl + 1.10 %MSG; T-4=1.10% $C_6H_5K_3O_7$ + 1.10% MSG; T-5=2.20% MSG.SEM, standard error of mean. nd, not detected.

Conclusion

Substitution of NaCl with KCl, MSG and $C_6H_5K_3O_7$ lowered sodium content and total COPs without compromising the sensorial quality of Kilishi.

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