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Deciphering nutrient composition of beef for different indigenous meat preservation methods in central Uganda

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Abstract
Livestock farmers in the rural communities of Uganda depend largely on indigenous preservation techniques as means of minimizing post-harvest losses in beef value chain. The nutritional quality of animal source foods is priority world over. The objective of this study was to decipher nutrient composition of beef for the different indigenous meat preservation techniques in Uganda. A cross sectional study was conducted in Nakaseke, Nakasongola and Sembabule districts using experimental-survey approaches. In the field survey, 90 respondents were interviewed using participatory techniques. Laboratory analysis examined 57 preserved meat samples. The results revealed two indigenous meat preservation techniques; Non-salted smoking (63.3%) and salted smoking (36.7%), largely (60%) practiced by females. Meat preservation is more frequent in dry season (93.3%). The results also showed that non-salted smoked and salted smoked meat had average moisture, fat and protein content of 21%, 14%, 67%; and 11%, 13% and 62% respectively. The average of zinc, iron and calcium content for the non salted smoked meat; 1.636 mg, 2.738 mg and 0.237 mg respectively while salt smoked meat; 2.341 mg, 3.587 mg and 0.609 mg respectively. The variations in nutrient composition of non salted smoked and salted smoked meat was insignificant (p>0.05). The authors conclude that the nutritional composition of traditionally processed meat products is maintained, particularly with high content of protein, fat, zinc, and iron. The indigenous meat preservation methods should be promoted and up-scaled due to enhanced nutrients and their potential to reduce of post-harvest losses. Additionally, develop standard operating procedures to prevent variations in processes of preservation techniques to assure nutritional quality of products.

Keywords: livestock products, post-harvest losses, indigenous preservation techniques

Introduction
Globally, meat and meat products are among the major foodstuffs in human nutrition and have been so for centuries (Valsta *et al.*, 2005) [57]. Meat is a nutritious but highly perishable food. The global demand for meat and meat products is on the rise and is projected to increase by 65% by 2020 (Bradford, 1999) [15] and 80% by 2050 (FAO, 2009) [21]. Meat provides nutrients such as essential amino acids, readily available proteins, fat-soluble vitamins (A, D, E, and K), water soluble vitamins (B complex) and minerals such as zinc, iron and phosphorus (Neumann *et al.*, 2002). Riboflavin and niacin from meat enhance skin health and the zinc enhances good vision (McAfee *et al.*, 2010) [38]. The conjugated linoleic acids (CLA) in meat is associated with many health benefits such as reduction of the severity of cholesterol induced aortic lesions, incidence of carcinogen induced mammary tumours and body weight gain (MacRae *et al.*, 2005) [34]. Currently, consumers are increasingly interested in the quality values and health attributes of animal source foods (Hocquette *et al.*, 2005) [27].
According to Ngulube (2002) [41], Africa possesses a wealth of knowledge in indigenous preservation techniques but these have not been fully utilized, developed and documented. In Uganda, indigenous meat processing and preservation practices are increasingly being used in rural areas especially in the cattle corridors.

These indigenous meat preservation methods maintain quality value of meat during storage and transportation over long distances (Mastromatteo *et al*., 2010) [37]. However, they are neglected and hardly documented, and information on nutritional quality of traditionally processed and preserved meat products is scanty (Ofor, 2011) [42]. It is recognized that processing and preservation of meat in Uganda is generally under-developed (UNFP, 2003) [56]. The plans of the government of Uganda to promote cost effective technologies of meat preservation under the Uganda National Food Policy have not been implemented (UNFP, 2003) [56]. Moreover, Oniang'o *et al.* (2004) [45] argues that promotion of indigenous technologies such as the preservation methods ensures sustained supply of food throughout the seasons and enhances income and nutrition at house hold level. The local communities have always had their own indigenous methods of meat processing and preservation. Unfortunately, most of these methods are not documented and neither are the nutritional composition of the processed products (meat) validated. This study documented and validated the processes of indigenous preservation techniques and ascertained the nutritional composition for their products.

Materials and Methods

Experimental –survey design was employed for this study which was conducted in Cattle corridor districts of Nakeseke, Nakasongola and Sembabule in Central Uganda. The sample size of respondents was determined using the formula by Bartlett *et al* (2001) [12];

$$n_{o}=\frac{(t)^2 x\ (p)\ (q)}{d^2}$$

Where; $n_{o}=$ the required sample size, t^2= value for selected alpha level from normal distribution for confidence interval of 95% =1.96, p= estimated population proportion and
d^2= acceptable margin of error for proportion being estimated.

In the field survey, the purposively selected cattle keeper households in Nakaseke, Nakasongola and Sembabule districts were interviewed using participatory techniques such as semi-structured interview and focus group discussions to document the indigenous meat preservation practices. Three focus group discussions were conducted; one per area of study; Nakasongola had twelve (12) participants; Sembabule had ten (10) participant and Nakaseke had eight (8) participants. The participants included men, women and youth with knowledge on indigenous meat preservation techniques. Semi-structured interviews were conducted at household level and a total of 90 respondents were interviewed using developed checklists with reference information concerning socio-demographic factors; meat preservation practices, processes of the indigenous preservation methods and quality checks and indicators of spoilage, among others.

Laboratory analysis

A total of fifty seven (57) traditionally preserved meat samples were collected from the respondents who were involved in the semi-structured interviews. The respondents were purposively selected based on use and knowledge of indigenous preservation techniques. Sixteen (16) NSS and seven (7) SS meat samples were collected from Nakaseke. Twelve (12) NSS and eight (8) SS meat samples were collected from Nakasongola. Nine (9) NSS and five (5) SS meat samples were collected from Sembabule. Additionally, 100 to 200g of NSS and SS meat samples were also collected, placed in commercial sterile stomach bags, then into an icebox with ice packs (to minimize microbial proliferation) and transported to the Department of Food Technology and Nutrition in Makerere University for chemical analysis. In the laboratory, the samples were refrigerated at 4˚C and analyzed within 24hour of collection according to Ariamalar *et al.*(2004) and Fakolade (2012) [19].

Chemical analysis

The samples were analyzed for moisture content (%), fat content (%), protein content (%) and then iron, zinc, calcium (mg/100g) of sample according to standard methods of the Association of Analytical Chemists (AOAC, 2005) and Analytical Methods for Atomic Absorption Spectroscopy (AAS, 1996) [1] respectively.
The qualitative data from the field was arranged into themes and coded; together with quantitave data from the laboratory was tarnscribed into Microsoft Excel (2007), later exported to statistical package for social science(SPSS version 20) for descriptive and inferential analyses. The descriptive analyses generated information represented as graphs and tables. Two-way ANOVA test was performed using Graph Pad 6.0 statistical software to understand the variations in the means of nutrient composition of processed meat products. Comparison across the treatments and districts of origin were done using Tukey multiple comparison test set at a significant level p<0.05.

Results

The study showed the respondents' socio-demographic factors as in Table 1 below:

Table 1: Socio-demographic factors of respondents

Parameters	Frequency (N)	Percentage (%)
Districts		
Nakaseke	30	33.3
Sembabule	25	27.8
Nakasongola	35	38.9
Gender		
Male	36	40
Female	54	60
Age		
21-30years	11	12.2
31-40 years	27	30
41-50 years	36	40
>50 years	16	17.8
Marital status		
Married	70	77.8
Single	20	22.2

Interestingly, the studies also found out that majority of the respondents (56.9%) have over 15 years experience in indigenous meat preservation. Largely (63.3%) use non-salt smoking technique and more frequently done during the dry season (93.3%) as shown in Table 2:

Table 2: Farmers experiences in Indigenous meat preservation Practices

Parameters	Frequency (N)	Percentage (%)
Experience in processing		
<5 years	13	14.4
5-10years	26	28.9
>15 years	51	56.9
Source of the knowledge		
Parents	23	25.6
Grand parents	67	74.4
Preservation techniques		
Non- salt smoking	57	63.3
Smoking after salting	33	36.7
Storage		
Kitchen(detached)	75	83.3
House in container	15	16.7
Shelf life of products		
2 -4 weeks	15	16.7
4 -8 weeks	46	51.1
>8 weeks	29	32.2
Quantity preserved per season		
<20kg	15	16.7
20-30kg	30	33.3
31-40kg	25	27.8
>50kg	20	20
Time of preservation		
Dry season	84	93.3
Festive season	6	6.7

Furthermore, the processes for two indigenous preservation methods were documented. Interestingly, procedures of meat preservation methods were slightly different in all the three districts as follows;

Non-Salt Smoking (NSS) technique

In Nakasongola district, fresh raw meat was placed on a metallic wire mesh (net) and placed over the fire place made of hot charcoal from firewood. The meat was then smoked for 2-3 hours daily for three (3) consecutive days. The smoked meat was placed in a bucket or sauce pan and kept in the house. Re-smoking was carried out on detection of bad odour, an indication of the spoilage process. The spoiled meat infiltrated with maggots in Nakasongola was re-heated/ re-smoked to attain the desirable flavor. In some households, meat was hanged in the kitchen for one day and smoked the following day.

In Sembabule, the meat was cut into small pieces, placed on a stick and smoked using hot charcoal from firewood. However for large quantities of meat, the charcoal is placed in a pit and the meat is placed on the metallic mesh (net) over that fire place. Smoking was carried out for 1-3 hours daily for up to a week depending on the quantity of the meat being smoked. The meat was stored in the kitchen above the fire place

In Nakaseke, meat was smoked until liquid stopped dripping from the meat. This usually lasted up to three (3) days of smoking for about 2 hours daily. The smoked meat was either kept in the house (hut) or in the kitchen. The meat was re-smoked on detection of bad odor. Generally, the storage period for preserved meat varied from 2 to > 12 weeks but most commonly 4 to 8 weeks (51.1%) which was equivalent to 1 to 2 months. The procedures of non-salt smoking preservation in the three districts in presented in process flow chart (Figure1).

Salted Smoking (SS) technique

In Nakasongola, the respondents reported that raw meat was salted on the first day and smoked the following day for a period of 2-3 hours daily for about 5 days. The smoked product was then stored in the saucepan or bucket in the house.

In Sembabule, meat was cut into small pieces, placed on a stick, salted and placed above the fire place (charcoal from firewood) for 1-2 hours daily for a period of 3 days. The smoked product was then stored in the kitchen right above the source of heat so that there is constant heat transfer to the meat to prevent spoilage.

In Nakaseke, meat was salted overnight and thereafter smoked daily for about 2-3 hours until the meat was deemed dry. It was then stored in the kitchen and only re-smoked on detection of bad odour. The procedures for Salt smoking preservation in the three districts in presented in process flow chart (Figure 2).

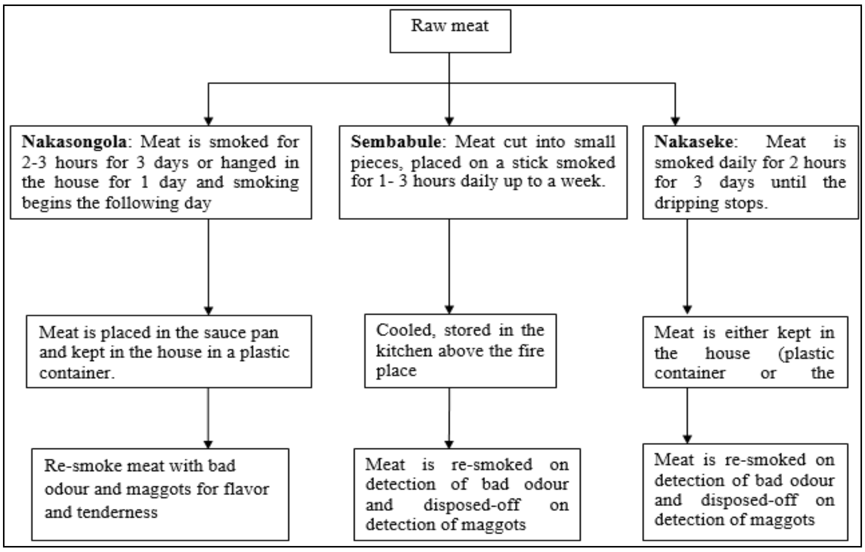

Fig 1: Procedure for non- salted smoking technique in the household

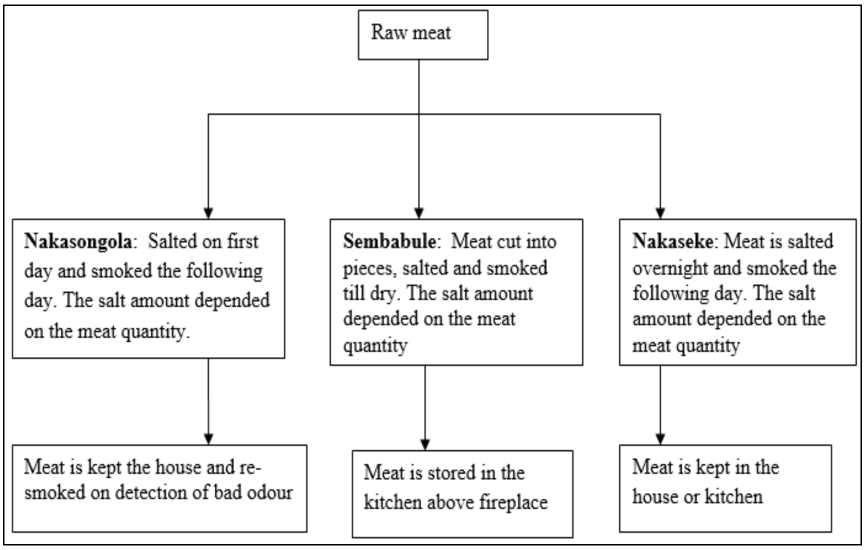

Fig 2: Procedure for salted smoking methods in the households

Farmer holding smoked meat (L) and storage in kitchen (R)

Samples of salt smoked meat (L) and non-salted smoked meat (R)

Furthermore, the results also revealed farmers reasons for practicing preservation methods (Figure 3); Assessment of quality of processed products and the common indicators of meat spoilage (Figure 4). However, the respondents stated that depending on the level of smoking (moisture content) of the smoked meat product and hygiene, the keeping quality can be maintained for up to six months.

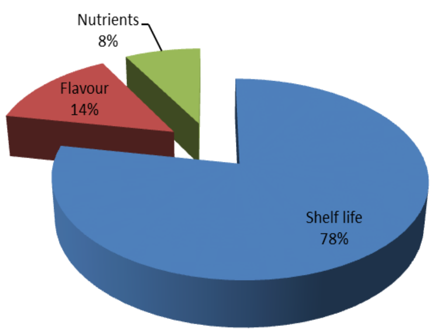

Fig 3: Reasons for practicing indigenous meat preservation techniques

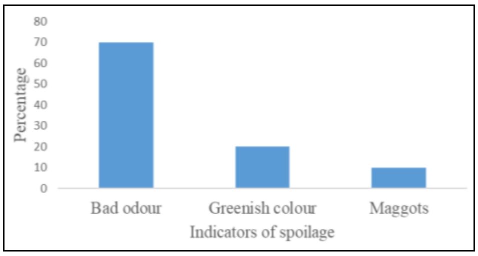

Fig 4: Signs of spoilage of processed meat.

The findings of nutrient composition of processed meat products revealed that non-salted smoked and salted smoked meat had highest concentration of fat and protein content 14%, 67%; and 13% and 62% respectively. Similarly, average iron was high both in non salted smoked meat and salt-smoked meat at 2.738 mg and 3.587 mg respectively as represented in Table 3 below:

Table 3: Means of Nutrients for the categories of processed meat products by districts

Parameter	Nakasongola		Sembabule		Nakaseke	
	NSS(12)	SS(8)	NSS(9)	SS(5)	NSS(16)	SS(7)
Fat (%)	15±9.9	16.2±1.87	10.4±0.96	8.6±0.90	13±9.6	12.6±2.65
Protein (%)	69±3.82	60.5±1.11	68±2.54	62.5±7.2	65±5.4	61±1.53
Moisture (%)	23.9±3.95	6±0.34	14.98±4.1	9.2±1.28	21±4.1	13.9±2.35
Iron (mg/100g)	1.6±1.1	2.37±0.27	3.2±1.0	2.78±0.32	3.4±0.32	4.6±0.57
Zinc(mg/100g)	1.54±0.5	1.27±0.19	2.0±0.1	1.87±0.25	1.5±1.0	3.1±1.1
Calcium(mg/100g)	0.06±0.07	0.29±0.08	0.47±0.32	1.04±0.81	0.34±0.24	0.3±0.08

Furthermore, the analysis model revealed that the variations in nutrient composition of non salted smoked and salted smoked meat were insignificant (p>0.05) (Table 4):

Table 4: Comparing the nutrient composition of processed meat by preservation methods

Parameter	NSS(37)	SS(20)	P-Value
Moisture (%)	21%±5.5	11%±3.699	0.098_{ns}
Fat (%)	14%±8.3	13%±4.801	0.482_{ns}
Protein (%)	74%±24.7	62%±5.855	0.251_{ns}
Zinc (mg/100g)	1.636 ±0.068	2.341±0.126	0.255_{ns}
Iron (mg/100g)	2.738 ±0.128	3.58±0.115	0.078_{ns}
Calcium(mg/100g)	0.237 ±0.027	0.609±0.072	0.178_{ns}

Subscript ns= no significant difference in the chemical composition of the meat samples from the different preservation methods.

Discussion

The meat industry is increasingly becoming one of the major contributors to food security, poverty alleviation and economic development especially in agro-based economies including Uganda. Smaller livestock holders largely contribute to the subsector despite glaring challenges of climate change, diseases, lack of preservation machines and tools, and post-harvest losses, among others. In the bid to mitigate the increasing post-harvest losses in the vulnerable rural communities especially in the dry season when the livestock are starving nearly to death due to inadequate pasture and water (NAPA, 2007; Sabiiti and Teka, 2004; Tanner, 2006) [40, 49].

Farmers are using their indigenous meat preservation techniques to process excess meat and prolong its shelf life, thus reducing of post-harvest losses in households. Unfortunately, these rudimentary techniques inevitably cause safety and nutritional quality concerns because of uncertainty of the processes.

This study was the first of its kind in Uganda, to promote an understanding of such valuable farmer's preservation practices through documentation of processes and laboratory analysis of the nutrient composition of the processed products (meat).

The study established that there are largely two indigenous preservation methods, namely; Non-salt smoking and salt-smoking techniques. Interestingly, the dry salting and smoking procedure is similar to that utilized in other African countries such as Nigeria and South Africa where firewood is also the major source of fuel for smoking meat (Mapiye *et al.*, 2007; Taiwo *et al.*, 1997) [36, 52].

On contrary, these methods differed from the nyirinyiri meat product by the Turkana women from Kenya which is preserved by deep frying the meat and kept in oil to extend the shelf life up to a year (Field, 2006) [23]. In another studies, also observed that these methods differed from the traditional fermentation method used on the different food products such as suya, a spiced and marinated meat product from Nigeria and terkin, a wet-salted fermented fish product from South Sudan (Abu-Hassan and Sulieman, 2011; Anihouvi *et al.*, 2012b; Oyewole and Isah, 2012) [2, 7, 46], sun-drying in Shona village in Zimbabwe and for Biltong in South Africa where preservation is by rubbing strips of meat with salt and spices before drying (Madovi, 1981; Naidoo and Lindsay, 2010) [35, 39]. The evident variation in meat preservation practices among countries could be largely attributed to the difference in culture and practices in the various communities.

Interestingly, the study revealed that meat preservation practice is predominantly an activity of women especially those who are married. This was in agreement with the research conducted by Achi (2005) [3] and Ibnouf (2012) [29] which emphasized the crucial role of women in agro-processing and food security in households. Additionally, it's recognized that largely the indigenous knowledge about meat preservation was got from the elderly (grandparents). This re-enforces the need to regularly document the technologies in communities otherwise, may be lost over time. This was consistent with Bora *et al.* (2014) [13] observation that the tendency of informal transfer of indigenous knowledge from one generation to another exist in many communities. Similar, the findings agree with Tapson (2013) [54], who established that the elderly are a hub of indigenous knowledge due to the experience they gain over time.

The findings also revealed that indigenous preservation techniques, prolonged the shelf life of the meat products. Indeed, the process of preservation reduces moisture content of the meat, thus, the water activity level to prevent the proliferation of microorganisms hence prolonging the keeping quality of the meat. Shelf life lasts as long as the sensory parameters were still deemed better based on the experience that they had acquired over time. These findings are similar to those reported by Engman *et al.* (2012) [18] and Oluborode *et al.* (2013) [44] that traditional smoking can preserve good sensory attributes of meat for a period of 30 weeks and 8 to 10 weeks respectively. Another researcher, noted that organoleptic tests can be used on various foods to give an initial indication of the food quality, although cannot be basis to recommend food as safe for human consumption (Luykx and Van Ruth, 2008; Perera, 2005) [33, 47]. Furthermore, the results show that these traditional techniques of meat preservation can be utilized by several cattle keeping communities affected by drought to reduce on the losses incurred by farmers during the dry season.

Regarding the nutritional quality of the processed products (meat), the major nutrients the two categories meat products (NSS and SS meat) were maintained, though, with slight variations. Water was much lower while fat and proteins were relatively higher that the recommended concentration 75% water, 23% protein and 2.5% lipid/ fat in fresh meat (Bosch, 2012; Fakolade, 2012; Heinz and Hautzinger, 2007) [14, 19, 26]. This is strongly in agreement with findings by Shavrukov (2012) [51], which revealed that the salt smoking meat had lower moisture content which is largely explained by the fact of preservative and dehydration effect of the salt. Similar findings were reported by Guizani *et al.* (2008) [25] that dry salting before smoking reduces the moisture content and water of activity at a faster rate than non-salted smoking. On the contrary, the results were slightly lower than the 79.2% crude protein reported by Akhter *et al.* (2009) [5].

The high crude protein content of the traditionally preserved meat samples is attributed to the anti-oxidative properties of smoke which hinder protein loss during processing and storage (Oluborode *et al.*, 2013; Xiong and Decker, 1995) [44]. This makes smoked meat a good source of proteins as recommended in the study by Akhter *et al.* (2009) [5]. However, this was greatly higher than the 92.75% crude protein content for raw beef documented by Adeniyi *et al.* (2011) [4] in Western Nigeria. However, it was observed that the variations may be due to the difference in the breed, age and environmental factors of the animals from which the meat was obtained (Hossain *et al.*, 1994) [28].

The crude protein content for the SS meat sample was lower than for the NSS samples, but slightly higher than the 58.1% of the salted, dried meat product known as Kundi from Nigeria (Fakolade and Omojola, 2008) [20]. The slight difference can be attributed to the variation in the preservation methods and the salt percentage used. The lower protein content for the salted meat samples is because salt solubilize the protein content leading to its decrease in meat (Bakheit and Khogalie, 2012; Keever, 2011) [10].

The results also reveals that the moisture content for the salted-smoked meat samples was slightly higher than the 9.75% for the kilishi (a salted sun dried meat product from Nigeria) but greatly different from the 25.8% for dendeng, a spicy traditional meat product from Indonesia (Idowu *et al.*, 2010; Purnomo, 2011) [31, 48]. The variation in the moisture content is attributed to the meat samples being obtained from the local people who depend on their personal experience and have no standard protocol for reducing to ascertain desirable moisture content.

The fat content of NSS and SS meat samples were higher than the 1.8% for fresh lean beef reported by Heinz and Hautzinger (2007) [26]. The fat content is also higher than the 3.2% and 3.77% for the raw non-salted and salted finely textured beef respectively (Christensen, 2012) [17]. The high fat content for the NSS and SS meat samples can be attributed to the loss of moisture (Idah and Nwankwo, 2013) [30]. On contrary, the crude fat content was slightly lower than the 18% documented for kilishi, a salted sun dried meat product from Nigeria (Idowu *et al.*, 2010) [31]. This difference is attributed to the difference in preservation technique and the loss of moisture which increased the fat concentration of the samples. The high protein and fat content for the NSS and SS meat samples was in agreement with Fiengor *et al.* (2008) [24].

The iron and zinc content of the two categories of processed meat products were found to be within the same range across the districts. However, the calcium content for all the meat samples was very low. This is attributed to the finding that meat is not a good source of calcium (Cáceres *et al.*, 2006; Tomé *et al.*, 2004) [16, 55]. Interestingly, the mineral content (zinc, iron and calcium) was higher in salt smoked meat products than for the NSS meat. This is because meat absorbs the sodium chloride and the same findings were documented by Okonkwo and Anyaene (2009) [43]. On the contrary, the zinc and iron levels for both preservation techniques was higher compared to the fresh meat as reported in a study by Williamson *et al.* (2005) [58], which revealed 4.7 mg and 2.4 mg per 100g of sample, respectively and Sainsbury (2009) [50] who documented 3.53 mg and 1.9 mg per 100g of sample respectively. Hence, suggesting an increase in the mineral concentration for the traditionally preserved meat. This in agreement with the research that recorded increase in mineral content for smoked and dried meat samples (Ayinsa and Maalekuu, 2013; Fiengör *et al.*, 2008) [9, 24]. Other studies also revealed that the iron content was also higher than for the variety of processed meat products such as meat balls and sausages which ranged from 0.8 mg – 1.4 mg/100g of sample (Kongkachuichai *et al.*, 2002) [32] and the 0.4 – 2.4 mg/100g of sample for processed turkey meat products (Ferreira *et al.*, 2000) [22]. This makes smoked meat a good source of iron in the diet.

Conclusions

The study has established that in the vulnerable rural communities, livestock farmers use non salt smoking and salt smoking techniques to preserve meat; particularly non-salt smoking technique. The processes of the indigenous preservation techniques have been found to maintain the nutrient composition in the preserved meat products; which is slightly higher particularly for the proteins, fats, zinc and iron, and lower moisture content. However, the mean variation of the nutrients in the two categories of preserved meat products is insignificant. Therefore, we argue that Indigenous meat preservation techniques should be promoted and up-scaled because they have increased potential to prevent post- harvest losses in meat value chain especially in the dry season. Additionally, the preserved meat products have enhanced nutritional benefits. A programme to create awareness among stakeholders and develop standard operating procedures for use along the meat value chain to prevent variations in the processes of preservation techniques to assure nutritional quality of products.

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