EFFECTS OF PROCESSING METHODS ON THE QUALITY OF PROCESSED MEATS SOLD IN THE RURAL AREAS OF NORTHERN NIGERIA

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Abstract: This study was carried out to investigate the effect of traditional meat processing on the nutritional, heavy metal and microbiological qualities. To this effect, some physico-chemical characteristics (moisture, proteins, fats, total ash, minerals and some heavy metals) were determined for fresh; sun dried and smoked dried meats while food-spoilage and pathogenic microorganisms were screened on the same samples. Results showed that the moisture content ranged from 61.352 – 82.383% for fresh meats, 9.442 – 14.512% for sun –dried meat and 7.443 – 9.553% for smoked dried meat. The smoked dried meats had the highest value of the protein 18.82±5.54 g/100 g and fresh meat had the lowest value of 13.161±4.632 g/100 g. The calcium content ranged from 0.065 – 0.099 mg/g for fresh meat, 0.075 – 0.199 mg/g for sun–dried meat and 0.055 – 0.089 mg/g for smoked dried meat. The concentration of magnesium ranged from 0.588 – 0.989 mg/g for fresh meat, 0.688 – 1.099 mg/g for sun dried meat and 0.488 – 0.789 mg/g for smoked dried meat. All the heavy metals examined in the processed meat have values that are below or within the maximum permissible limit of WHO, FAO and EC Standards.

Keywords: Consumed, meat quality, local processing, rural areas, smoking drying, sun drying.

Introduction

Meat is very rich and convenient source of nutrients including microelements. Mineral and proximate composition of meat depends on both the kind and degree of the feeding and meat processing of the animal (Zamil El-Faer *et al.*, 1991). In olden days, before refrigerators and freezers, smoking and drying of meat was a necessity. In Nigeria like most other African countries preserved their meat by slow-cooking it over a smouldering flame. The process also yielded sweet-smoked, woody flavour. Today it's no longer necessary to "hold the fire," and while we appreciate smoked meat for being ready-to-eat with no added fat, sometimes we are addicted to that smoky taste. Smoked and sun dried meat has been the most common preserved food used by peoples of all cultures, (Aranha, 1994).

Indeed, smoking of meat was well-developed not long after fire was discovered. The use of heavily smoked meats and fishes came into being because of both the need to prevent spoilage and to provide a food reserve for long time. Although the original reason for smoking meat had been to preserve it, the main reason today is for enjoyment of the mild smoky flavour.

Refrigeration and efficient transportation systems have dramatically decreased the dangers of spoilage (Demirezen & Uruç, 2006), notwithstanding meat being a highly perishable food, whether meat is preserve on a commercial scale or for domestic consumption of the meat, smoking and sun–drying is the preferred cheap method of preventing its spoilage. This is carried out over smouldering wood, saw dust or other local sources of energy using traditional kilns constructed with locally sourced materials (Doganoc, 1996).

Most of the communities in States of North central Nigeria consumed meat throughout the year. However, most of the people are largely of the peasant class with limited exposure to modern meat preservation technology. So most of the meats are processed and preserved through smoking and this is carried out over smouldering wood, sawdust or other local materials such as plastic robber and other items so that smoked meat obtained in the market have tremendously variable quality (Gonzalez-Waller *et al.*, 2006; Goyer, 1979). Good hygienic conditions, therefore, could enhance meat quality, but it seems that not much can be done to exclude contamination by minerals. These are introduced by the smoke in addition to those absorbed through ingestion of contaminated food or through processing and preservation and concentrations could reach toxic levels.

On the other hand, nutritional losses resulting from preservation processes have been reported (Cunningham & Saigo, 1997). Incidences such as these are likely to affect product quality of meat adversely. Thus, as dried meat continues to occupy its important place as a delicacy in the dishes of people of North Central Nigeria and other parts of the country and technologies and processing employed in smoking remain underdeveloped, the dangers of possible contamination of smoked products need to be brought to the fore. The consumption of local processed meat may impose health hazards on humans. Despite the importance of meat processing and storage, very few investments are realized in this sector in view of modernizing the activity as well as improving meat processing and preservation tool. With regard to fresh meat storage, it is estimated that 35% are lost due to the lack of cold chain. Local population have developed traditional meat processing techniques that make use of available natural means, namely sun and wood. In this respect, they are mainly sun-dry and smoke-dry more than 75% of fresh meat and this meat processing is usually carried out by elder people (Daniel & Edward, 1995).

The method includes washing and draining prior to sun-drying or smoke-drying. For sun-drying, meat is exposed to sun and free air and is turned over from time to time during 48-72 h depending on the size of meat and the intensity of sun. Smoking-drying is carried out in terracotta smoking-rooms using various wood species. meat are smoked for 2-3 h at 70 – 80°C, followed by mild smoking (30 – 35°C) for 24-48 h. But the technology employed by local people is not standardized and most parameters remain uncontrolled. Hence, such essential drying parameters as duration, air humidity and

temperature are not precisely determined and mastered. In addition, hygienic conditions of meat killed, processing and storage are questionable. These might impact on nutritional value and safety of processed meat with possible food toxic-infections and again many metals and metallic compounds found in the material used for processing of the meat pose a risk to human health through the consumption of such meat, wherein contaminant concentration and exposure are significant. It is important to determine the concentrations of heavy metals in local processed meat in order to evaluate the possible risks of meat consumption for human health (Horky *et al*., 1998).

Many studies have been published on the determination of heavy metals in meat and meat products (Janet & Carl, 1994; Johnson, 1993), but these studies are inadequate for estimating the intake of these heavy metals by humans especially in the remote and rural area since they were carried out mostly in urban and advance area.

It was, important and necessary to conduct this study to determine the concentrations of some heavy metals in local processed meat in some rural areas of North central part of Nigeria and compare the levels with those of standard. The present study was therefore carried out to investigate the effect of traditional meat processing techniques (sun-drying and smoking-drying) on the heavy metals, nutritional value and some microbiological quality of local processed meat consumed in rural areas of North central part of Nigeria and compare the levels with those of standard

Materials and Methods

Samples and sample collection

The study focused on the most common and popular consumed meat from domestic animals sold in some of the rural market areas of Abuja, Benue, Kogi, Nassarawa in North Central, Nigeria. For each species, fresh, smoke-dried and sun-dried meats were studied. The samples of meats are cow meat (beef), sheep meat (mutton), goat meat (caprine) pig meat (pork) and foul meat (chicken) were bought from different markets in the study areas (North central) state, Nigeria. Upon purchase, the meats were stored in sterile plastic bags under vacuum and transported in cool bags to the laboratory for analyses.

Sample preparation and analytical methods

The collected samples were decomposed by wet digestion method for the determination of various metals. Samples were treated in triplicate and analysis was carried out following EPA Method 3050B Digestion Procedures. 1.00 g of sample (muscle) was placed in 250 ml flask for digestion. The first step was to heat the sample to 95^0C with 10 ml of 50% HNO_3 without boiling. After cooling the sample, it was refluxed with repeated additions of 65 % HNO_3 until no brown fumes were given off by the sample. Then the solution was allowed to evaporate until the volume was reduced to 5 cm^3. After cooling, 10 ml of 30% H_2O_2 was added slowly without allowing any losses. The mixture was refluxed with 10 cm^3 of 37% HCl at 95^oC for 15 min. The digestate obtained was filtered through a 0.45 µm membrane paper, diluted to 100 cm^3 with deionized water and stored at 4^0C for analyses.

Determination of the nutritional value

For each species, 1.00 g of fresh, sun-dried and smoke-dried meats were analyzed. The water contents and of total ashes were determined by standard method (AOAC, 1995). Total lipids were extracted in soxhlet using hexane and were measured according to the Russian method (Mahaffey, 1977). Crude proteins were mineralized according to Kjeldhal and nitrogen obtained was measured (McLaughlin *et al.*, 1999). Crude proteins content was obtained by multiplying the nitrogen content by the conventional factor of 6.25. Minerals and heavy metals (K, Mg, Na, Zn, Ni, Cd, Pb, Cr) were determined by atomic absorption spectrometry (AAS 50B, Australia). Sensory quality of meat, more precisely oxidative rancidity was determined by measuring Thiobarbituric Acid Reactive Substances (TBA-RS) according to the method described by Witte *et al.* (1970). The microbiological quality of meat was evaluated using the method described by Mukhacheva & Bezel (1995). Spoilage and pathogenic microorganisms were screened on 10 folds dilutions of meat samples. 1 g of fish muscles was weighed aseptically and homogenised in 10 cm^3 sterile peptone water. Serial dilutions of the mixture were prepared and 0.1 ml of diluents was spread on already prepared plates of nutrient agar. Duplicate plates were incubated at 25 ± 5^oC for 24 h. The total colonies were counted to represent the total number of bacterial cells (TVC) capable of forming colonies (John & Jeanne, 1994).

Statistical analyses

Data collected were presented as mean and standard deviation and were subjected to one-way analysis of variance (ANOVA) ($p<0.05$) to assess whether heavy metals varied significantly between processed meats. All statistical calculations were performed with SPSS 9.0 for Windows (Ozdamar, 1991).

Results and Discussion

The results of physico – chemical and proximate composition of the traditional and local processed meat in some markets in the study areas are presented in Table 1, 2, 3. The moisture levels in all the dried meat samples examined were below 20% which is good and acceptable for sun dried and smoked dried meats. The moisture content ranged from 61.352 – 82.383% for fresh meats, 9.442 – 14.512% for sun –dried meat and 7.443 – 9.553% for smoked dried meat. Moisture contents of fresh meats were relatively high with average value of 71.199±6.596 and were significantly different from sun–dried and smoked dried meats at ($p>0.05$). The moisture contents of fresh meats were high (71.199±6.596) and are one of the factors which could increase meat spoilage. Preservation treatment, (sun-drying and smoke-drying) reduced moisture contents to values less than 15%. The highest value recorded for sun – dried processed meat was 14.512% and 9.553% for smoked dried processed meats. In all the meat samples studied, sun-dried processed meats contained more residual moisture than smoke-dried processed ones i.e. 12.2656±1.737 and 8.599±0.691% respectively for the sun-dried and smoke-dried meats. This could be explained by the fact that during smoke-drying the flesh meat loses water in the initial phase that could be due to high temperature and after a while, a protective coating is formed due to partial carbonization of tissue and other components by wood smoke. Smoke-dried meats are better processed and preserved and have lower moisture contents than those found sun – dried and fresh processed meats.

Table 1: Physicochemical Characteristics of fresh processed meat

Parameters	Moisture content (%)	Total Ash (%)	Protein (%)	Lipid (%)	TBARS
AF1	75.476	2.006	40.180	1.005	0.120
AF2	64.521	1.908	40.120	1.004	0.110
AF3	73.234	2.609	30.210	1.504	0.100
AF4	82.383	2.005	30.190	1.008	0.200
AF5	65.512	1.506	35.170	1.007	0.090
AF6	61.352	1.508	40.160	1.006	0.110
AF7	75.443	2.005	30.130	1.007	0.080
AF8	64.582	2.104	40.140	1.007	0.070
AF9	72.521	1.809	40.190	1.006	0.110
AF10	70.393	1.708	35.160	1.005	0.140
AF11	61.622	2.100	30.110	1.008	0.130
AF12	73.553	2.021	35.140	1.007	0.090
AF13	81.622	1.603	40.150	1.008	0.080
AF14	70.442	2.105	30.180	1.005	0.070
AF15	75.323	2.304	30.110	1.009	0.110
MEAN	71.198	1.953	35.156	1.039	0.107
STD	6.596	0.297	4.630	0.129	0.033
MIN	61.352	1.506	30.110	1.004	0.070
MAX	82.383	2.609	40.190	1.504	0.200

Table 2: Physicochemical characteristics of sun dried processed meat

Parameters	Moisture content (%)	Total Ash (%)	Protein (%)	Lipid (%)	TBARS
BS1	14.476	3.5001	45.180	2.505	0.800
BS2	13.521	4.908	48.120	3.320	0.900
BS3	12.234	3.609	47.210	3.504	0.700
BS4	11.383	4.505	40.190	2.508	0.800
BS5	14.512	4.506	45.170	3.007	0.850
BS6	10.352	3.708	48.160	3.007	0.940
BS7	14.443	3.601	48.130	3.007	0.850
BS8	13.582	5.104	49.140	3.007	0.760
BS9	11.521	4.809	40.190	3.506	0.730
BS10	10.393	4.708	48.160	3.585	0.850
BS11	10.622	4.501	45.110	2.808	0.760
BS12	12.553	5.021	48.140	3.007	0.920
BS13	10.622	3.803	40.150	2.808	0.640
BS14	9.442	4.505	48.180	3.505	0.930
BS15	14.323	4.304	41.110	3.009	0.750
MEAN	12.266	4.339	45.489	3.073	0.812
STD	1.776	0.555	3.411	0.348	0.089
MIN	9.442	3.501	40.150	2.505	0.640
MAX	14.512	5.104	49.140	3.585	0.940

The total ash content ranged from 1.506 – 2.609 % for fresh meat, 3.501 – 5.104% for sun dried meat and 6.101 – 8.708% for smoked dried meat. Total ash contents in fresh processed meats were low with average value of 1.953±0.297 %, while the sun-dried and smoke-dried meat had average values of 4.339±0.555% and 7.332±0.537 %, total ash contents of sun–dried and smoked dried were higher because of water loss related to these treatments. The ash content gives a measure of the total mineral content in the tissue (Nair and Mathew, 2001). The variability in the body composition of the traditional processed meat has been attributed to several factors such as environment, age, size, diet and species (Lashen, 2000) but the basic causes of change in composition are usually variation in the amount and quality of food it eats and health condition of particular animals (John & Jeanne, 1994).

The results of the protein contents of all the processed meats were not significantly different from one to another. Values obtained varied from 13.156±4.630, 14.489±3.411 and 18.823±5.543 g/100 g for fresh, sun–dried and smoked dried respectively. The results show that the traditional methods of meat processes did not significantly influence the content and composition of proteins. In effect, other studies revealed that muscular proteins content does not vary significantly with the age and is not influenced by the composition of animals feed (Jamin and Ayinla, 2003). Moreover, all processed meat from the study areas exhibit protein contents quite similar to those of sheep meat (17.2 g/100 g), cow meat (19.6 g/100g) and pork (19.4 g/100g) (Krupa & Swida, 1997). Meat is a good source of protein and significant amounts were obtained from processed meats with an average value of 13.156±4.630, 14.489±3.411 and 18.823±5.543 g/100g for fresh meat, sun–dried and smoked dried respectively, with the highest value recorded for smoke-dried products. The increase in protein contents may be due to product dehydration which concentrated proteins, thus increasing the nutritional value of smoked meats. Similar results were obtained in similar studies (McLaughlin, *et al* 1999). The relatively high to moderate percentage of crude protein could be attributed to the fact that meat are good sources of pure protein, but the little differences observed may also be attributed to meat processing, animal's consumption or absorption capability and conversion potentials of nutrients from their diet or local environment into such biochemical attribute needed by the organism's body (Miranda, *et al* 2005).

The lipid value ranged from 1.004–1.504, 2.505–3.585 and 2.006–2.907%, these values are slightly raised by sun-drying and smoke-drying. The greatest increase was observed on the sun-dried meat (3.0729±0.3477 g/100 g). The low increase in lipid contents could be explained by possible losses during various heat treatments. Furthermore, studies revealed that lipid contents fluctuate considerably with age, feed and sexual cycle of the animals (Murray and Burt, 2009).

Table 3: Physicochemical characteristics of smock dried processed meat

Parameters	Moisture content (%)	Total Ash (%)	Protein (%)	Lipid (%)	TBARS
CS1	8.476	8.506	60.180	2.568	0.400
CS2	8.521	7.000	60.120	2.320	0.500
CS3	9.234	6.909	50.210	2.504	0.400
CS4	9.383	6.905	60.190	2.508	0.500
CS5	8.512	6.506	50.170	2.007	0.400
CS6	8.352	7.508	60.160	2.006	0.500
CS7	7.443	6.805	50.130	2.907	0.500
CS8	8.582	7.104	60.140	2.807	0.300
CS9	8.521	6.809	45.190	2.007	0.400
CS10	9.393	8.708	55.160	2.085	0.300
CS11	7.622	6.101	52.110	2.008	0.420
CS12	9.553	7.102	53.140	2.007	0.520
CS13	7.622	8.603	65.150	2.008	0.350
CS14	9.442	6.905	55.180	2.505	0.420
CS15	8.323	8.504	60.110	2.509	0.320
MEAN	8.599	7.332	55.823	2.317	0.415
STD	0.691	0.837	5.543	0.319	0.076
MIN	7.443	6.101	45.190	2.006	0.300
MAX	9.553	8.708	65.150	2.907	0.520

The values of macro elements of the traditional processed meat in the study areas are shown in Table 4, 5, 6. The calcium content ranged from 0.065 – 0.099 mg/g for fresh meat, 0.075 – 0.199 mg/g for sun–dried meat and 0.055 – 0.089 mg/g for smoked dried meat. The concentration of magnesium in traditional processed meat in the study areas ranged from 0.588 – 0.989 mg/g for fresh meat, 0.688 – 1.099 mg/g for sun dried meat and 0.488 – 0.789 mg/g for smoked dried meat. The potassium concentration ranged from 1.388 – 2.877 mg/g for fresh meat, 2.014 – 2.189 mg/g for sun dried meat and 1.065 – 2.121 mg/g for smoked dried meat. The sodium concentration ranged

from 0.477 – 0.788 mg/g for fresh meat, 0.577 – 0.888 mg/g for sun dried meat and 0.417 – 0.708 mg/g for smoked dried meat. Calcium, magnesium, potassium and sodium are abundant in all the traditional processed meats studied. The present study showed all traditional processed meats are good sources of mineral elements. In smoke dried samples, the lower values of some major elements were reported compared with sun dried methods for instance the Ca average value is 0.072±0.011 and K average value is 1.529±0.495 in smoked dried processed meat while same elements in sun–dried processed meat had the values of 0.104±0.039 and 2.094±0.052 for Ca and K, respectively. The studies showed that smoke- dried meats were still good sources of macro and micro mineral elements in spite of the processing effects of smoking. It may be noted that the mineral composition of each species is a function of the availability of these mineral in their local environment, diet absorptive capability and as well as their preferential accumulation (Okoko, 1996). However, it was discovered that micro elements recorded very low values; this may be due to the fact that the body demands them in trace amounts and that their concentration in their feeding sources is very low. Moreover some minerals might have been lost during processing of the meats (FAO, 1981).

Table 4: Mineral composition of fresh meat (mg/g)

Elements	Ca	Mg	K	Na
AF1	0.088	0.688	1.388	0.588
AF2	0.065	0.765	2.321	0.665
AF3	0.088	0.588	2.089	0.688
AF4	0.098	0.798	2.065	0.579
AF5	0.069	0.869	1.988	0.769
AF6	0.098	0.986	2.877	0.699
AF7	0.087	0.787	2.319	0.587
AF8	0.082	0.982	1.988	0.582
AF9	0.069	0.769	1.769	0.569
AF10	0.089	0.989	2.069	0.585
AF11	0.068	0.868	1.897	0.668
AF12	0.089	0.789	2.135	0.589
AF13	0.077	0.877	2.035	0.477
AF14	0.079	0.679	2.099	0.579
AF15	0.088	0.988	1.988	0.788
MEAN	0.083	0.828	2.068	0.628
STD	0.011	0.125	0.315	0.083
MIN	0.065	0.588	1.388	0.477
MAX	0.099	0.989	2.877	0.788

The values of the heavy metals of traditional processed meat are shown in Table 7, 8, 9. All the heavy metals considered Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn were detected in various concentrations in all the samples purchased from various locations of the study areas. In the fresh samples studied, the overall results ranged from 0.001 – 0.004, 0.011 – 0.029, 0.023 – 0.079, 0.179 – 0.251, 0.079 – 0.211, 0.021 – 0.035, 0.011 – 0.028 and 1.098 – 1.997 mg/g for Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn, for sun dried processed meat the overall results ranged from 0.001 – 0.002, 0.001 – 0.003, 0.024 – 0.039, 0.110 – 0.199, 0.089 – 0.321, 0.001 – 0.002, 0.012– -0.033 and 1.011–1.997 mg/g for Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn, while for smoked dried processed meat the overall results ranged from 0.001 – 0.003, 0.001 – 0.004, 0.024 – 0.047, 0.110 – 0.202, 0.089– 0.421, 0.001 – 0.003, 0.012 – 0.043 and 1.011 – 2.987 mg/g for Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn, respectively.

Table 5: Mineral composition of sun dried meat (mg/g)

Elements	Ca	Mg	K	Na
BS1	0.098	1.099	2.099	0.888
BS2	0.097	0.788	2.039	0.688
BS3	0.075	0.865	2.032	0.765
BS4	0.098	0.688	2.189	0.788
BS5	0.198	0.898	2.165	0.679
BS6	0.079	0.969	2.099	0.877
BS7	0.199	1.099	2.088	0.769
BS8	0.097	0.887	2.032	0.659
BS9	0.092	1.098	2.099	0.682
BS10	0.079	0.868	2.077	0.769
BS11	0.099	1.099	2.169	0.685
BS12	0.078	0.968	2.088	0.768
BS13	0.099	0.889	2.014	0.689
BS14	0.087	0.977	2.104	0.578
BS15	0.089	0.779	2.109	0.658
MEAN	0.104	0.931	2.094	0.729
STD	0.039	0.129	0.052	0.084
MIN	0.075	0.688	2.014	0.577
MAX	0.199	1.099	2.189	0.888

Table 6: Mineral composition of smoked dried meat (mg/g)

Elements	Ca	Mg	K	Na
CS1	0.078	0.588	1.088	0.488
CS2	0.055	0.665	2.121	0.565
CS3	0.078	0.488	1.089	0.588
CS4	0.088	0.698	1.065	0.479
CS5	0.059	0.769	1.088	0.669
CS6	0.089	0.786	2.077	0.609
CS7	0.077	0.687	2.019	0.507
CS8	0.072	0.782	1.088	0.482
CS9	0.059	0.568	1.069	0.509
CS10	0.079	0.789	2.009	0.505
CS11	0.058	0.668	1.089	0.608
CS12	0.079	0.486	2.035	0.509
CS13	0.067	0.677	2.005	0.417
CS14	0.069	0.579	2.009	0.539
CS15	0.068	0.788	1.088	0.708
MEAN	0.072	0.668	1.529	0.546
STD	0.011	0.105	0.495	0.078
MIN	0.055	0.488	1.065	0.417
MAX	0.089	0.789	2.121	0.708

All the meat samples studied contain heavy metal and their concentrations were similar in different samples examined, the similarity of the results in the different meat samples is an indication that the meat processing methods are also similar in all the studied areas. Because of the complicated pattern in the concentration relationship of the samples, focusing on the comparison between the various meat processing methods will be futile; instead, the general profile of the meat quality in respect to each parameter will be discussed.

Table 7: Heavy metal content of fresh meat (mg/g)

Points	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	0.001	0.001	0.039	0.181	0.122	0.001	0.021	1.123
2	0.003	0.002	0.029	0.152	0.131	0.001	0.031	1.971
3	0.002	0.001	0.036	0.198	0.201	0.002	0.012	1.554
4	0.001	0.001	0.029	0.125	0.144	0.001	0.024	1.011
5	0.002	0.002	0.028	0.133	0.175	0.002	0.033	1.876
6	0.002	0.002	0.024	0.186	0.166	0.001	0.025	1.997
7	0.002	0.003	0.030	0.122	0.098	0.003	0.025	1.543
8	0.001	0.001	0.030	0.179	0.144	0.001	0.022	1.234
9	0.002	0.004	0.034	0.121	0.089	0.002	0.032	1.543
10	0.001	0.001	0.025	0.116	0.201	0.001	0.031	1.675
11	0.002	0.002	0.026	0.202	0.421	0.001	0.043	1.654
12	0.002	0.003	0.047	0.112	0.132	0.001	0.025	1.098
13	0.001	0.002	0.030	0.110	0.141	0.001	0.031	1.133
14	0.002	0.001	0.026	0.189	0.122	0.003	0.031	1.098
15	0.001	0.003	0.030	0.140	0.171	0.001	0.028	2.987
Mean	0.001	0.002	0.030	0.151	0.157	0.001	0.026	1.499
Std.	0.001	0.001	0.005	0.034	0.056	0.001	0.006	0.360
MIN	0.001	0.001	0.024	0.110	0.089	0.001	0.012	1.011
MAX	0.003	0.004	0.047	0.202	0.421	0.003	0.043	2.987

Table 8: Heavy metal content sun dried meat (mg/g)

Points	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	0.001	0.001	0.039	0.181	0.122	0.001	0.021	1.123
2	0.001	0.002	0.029	0.152	0.131	0.001	0.031	1.971
3	0.002	0.001	0.036	0.198	0.201	0.002	0.012	1.554
4	0.001	0.001	0.029	0.125	0.144	0.001	0.024	1.011
5	0.002	0.002	0.028	0.133	0.175	0.002	0.023	1.876
6	0.001	0.002	0.024	0.186	0.166	0.001	0.025	1.997
7	0.002	0.003	0.029	0.122	0.098	0.001	0.025	1.543
8	0.001	0.001	0.029	0.179	0.144	0.001	0.022	1.234
9	0.001	0.003	0.034	0.121	0.089	0.002	0.032	1.543
10	0.001	0.001	0.025	0.116	0.201	0.001	0.031	1.675
11	0.002	0.002	0.026	0.199	0.321	0.001	0.033	1.654
12	0.002	0.003	0.037	0.112	0.132	0.001	0.025	1.098
13	0.001	0.002	0.029	0.110	0.141	0.001	0.031	1.133
14	0.001	0.001	0.026	0.189	0.122	0.002	0.031	1.098
15	0.001	0.003	0.029	0.140	0.171	0.001	0.028	1.987
Mean	0.001	0.002	0.029	0.151	0.157	0.001	0.026	1.499
Std.	0.001	0.001	0.005	0.034	0.056	0.001	0.006	0.360
MIN	0.001	0.001	0.024	0.110	0.089	0.001	0.012	1.011
MAX	0.0020	0.0030	0.039	0.199	0.321	0.002	0.033	1.997

Table 9: Heavy metal content of smoked dried meat (mg/g)

Points	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
1	0.002	0.023	0.043	0.251	0.122	0.025	0.012	1.231
2	0.001	0.012	0.023	0.232	0.131	0.025	0.017	1.971
3	0.004	0.022	0.065	0.198	0.165	0.035	0.012	1.554
4	0.004	0.011	0.079	0.225	0.144	0.027	0.011	1.767
5	0.003	0.012	0.068	0.233	0.175	0.031	0.013	1.876
6	0.001	0.028	0.053	0.186	0.166	0.027	0.018	1.997
7	0.001	0.017	0.069	0.222	0.098	0.032	0.021	1.543
8	0.002	0.021	0.059	0.179	0.144	0.027	0.016	1.234
9	0.002	0.025	0.032	0.221	0.089	0.024	0.011	1.543
10	0.002	0.029	0.043	0.216	0.201	0.031	0.019	1.675
11	0.002	0.026	0.044	0.199	0.078	0.025	0.014	1.654
12	0.003	0.019	0.033	0.212	0.132	0.025	0.012	1.098
13	0.001	0.018	0.044	0.210	0.141	0.035	0.013	1.123
14	0.002	0.029	0.039	0.189	0.211	0.021	0.011	1.543
15	0.002	0.023	0.039	0.240	0.171	0.025	0.028	1.987
Mean	0.002	0.021	0.049	0.214	0.145	0.028	0.015	1.586
Std.	0.001	0.006	0.016	0.021	0.038	0.004	0.005	0.307
Min	0.001	0.011	0.023	0.179	0.078	0.021	0.011	1.098
Max	0.004	0.029	0.079	0.251	0.211	0.035	0.028	1.997

Pb was detected in the meat samples and Pb continues to be a significant public health problem in developing countries where there are considerable variations in the sources and pathways of exposure, therefore care need to be taking in the consumption of Pb contaminated meat and meat products since Pb exposure is through direct contact. It was investigated and it has been shown that exposure to Pb can lead to a wide range of biological defects in human depending on duration and level of exposure. Cadmium was detected in the meat samples in the range of 0.001 to 0.004 mg/g and cadmium when ingested by humans; it accumulates in the intestine, liver and kidney (Reddy & Yellamma, 1996). It is also reported that Cd can affect Ca, P and bone metabolism in both industrial and people exposed to Cd in general environment (Jarup *et al*., 1998). Highest cadmium concentration recorded in the meat samples studied was 0.004 mg/g. From the results of this study, the concentration of cadmium in all the samples studied were found to be lower than the 0.5 mg/g permissible limit set by (FAO/WHO, 2000)

Chromium is considered non-essential for plants, but an essential element for animals. Cr toxicity in man has been limited to haemorrhage, respiratory impairment and liver lesions. Levels of Ni in all the meat samples were similar, the slight differences in their concentration were statistically not significant ($p<0.5$). It is important to note that Ni concentrations in all the meat samples investigated were lower than what was obtained by other researchers in the similar studies (Maldonado *et al.,* 1996).

Copper and iron are classified as essential to life due to their involvement in certain physiological processes, but elevated levels of these elements, however, have been found to be toxic. Copper and Fe form the essential group of metals required for some metabolic activities in organisms. The mean and range values of the Cu, Fe and Mn in the all samples of meat studied revealed that the highest levels of these metals (0.321 mg/g) were lower than the limit level for standard for World Health Organization (FAO, 1981).In this study, the highest amount of Zn (1.997 mg/g) found in the samples is much lower than the permissible level of 250: mg/g (Sabir *et al.,* 2003).

Table 10: Daily total viable count results of processed meat samples (X 10^6 cfu/ml)

Samples	Fresh meat	Sundried meat	Smoked dried meat
Day 1	0.000	0.000	0.000
Day 2	4.500	2.950	1.231
Day 3	8.345	4.555	3.331
Mean	4.282	2.502	1.521
Std	4.177	2.310	1.684
Min	0.000	0.000	0.000
Max	8.345	4.555	3.331

The results of the total viable count (Table 10) of preserved meat samples showed a significant difference ($p<0.05$) between the total viable count of fresh, sun–dried and smoked meat. The smoked meats had the lowest TVC out of the processing meats studied. The introduction of heat during all the processing methods would not only kill microorganisms but will also reduce the moisture content of the meat making the environment less favourable for microbial growth(Stirling 1985). However, heating does not destroy all organisms as some organisms may survive in dried meat after heating, accounting for the higher microbial count of dried meat samples. The inclusion of salt (in the case of sun dried samples) and smoke samples) along with heating usually provides a more efficient method of processing, accounting for the lower microbial count in sun dried and smoked samples (Doganoc, 1996). TVC of meat samples increased significantly ($P<0.01$) with increase in the duration of storage. As the duration of storage increase, processed meat samples may absorb small amounts of moisture from surrounding atmosphere providing enabling environment for microbial growth (Cunningham & Saigo 1997). By the 6th week, sun dried and smoked dried samples of meat studied had total viable counts exceeding 5.7 (Log_{10} cfu/g). The highest total viable count was recorded for smoked dried samples: 6.592 ± 0.112 (Log_{10} cfu/g)

Conclusions

The studies therefore showed that traditional processed meat (fresh meat, sun dried meat and smoke- dried meat were still good sources of macro and micro elements in spite of the processing effects. It may be noted that the mineral content of each species is a function of the availability of these elements in their local environment, diet absorptive capability and as well as their preferential accumulation (FAO/WHO, 2000). It was discovered that trace elements recorded very low values; this may be due to the fact that their concentration in the body is very low and the body demands them in trace amounts. Moreover some minerals might have been lost during processing of the meat.

Although all the heavy metals determined were present in all the processed meat samples analyzed but the present concentrations may not pose any serious health hazard since all parameters examined in the meat samples have values that are below or within the maximum permissible limit of WHO, FAO and EC Standards, but attention should be given to Cd, Ni and Pb which could be harmful to human after prolong exposure to these metals even at low concentration. It can be concluded that local processed meats is safe for consumptions and could serve as a source of nutrient intake for the local people that consume it.

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