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COMPARISON ON THE EFFECT OF FREEZING PERIOD ON THE pH AND MINERAL CONTENT OF MEAT, TILAPIA AND CATFISH SOLD WITHIN KADUNA NORTH AND SOUTH LOCAL GOVERNMENT AREAS OF KADUNA STATE

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ABSTRACT
Cow, Ram, Goat, Catfish (*Clarius gariepinus*) and Tilapia fish (*Oreochromis noliticus*) flesh were examined for pH and mineral elements during a freezing period from Day 1- Day 30. The pH of the meat/fish samples were determined using a pH meter; the mineral content (Fe, Mg and Ca) were determined using the Atomic Absorption Spectrophotometer, while Na and K were determined using Flame Photometry. The mean mineral element contents of the meat and fish in the analysed period were Fe (0.69±0.22), Na (5.41±0.71), K (2.70±0.43), Mg (1.09±0.14) and Ca (0.46±0.16) for Cow. Fe (1.10±0.74), Na (5.92±1.22), K (2.49±0.14), Mg (0.90±0.28) and Ca (0.33±0.10) for Ram. Fe (0.85±0.54), Na (6.77±1.74), K (2.27±0.49), Mg (0.85±0.24) and Ca (0.40±0.17) for Goat. Fe (0.85±0.42), Na (5.36±0.65), K (2.91±0.35), Mg (1.11±0.06) and Ca (0.38±0.05) for Catfish. Fe (1.15±0.92), Na (6.58±0.42), K (2.70±0.33), Mg (1.35±0.37) and Ca (0.63±0.21) for Tilapia. All mineral contents were below the Recommended Dietary Intake due to the storage effect. It is therefore recommended that fresh meat and fish storage in refrigerators should not be for more than 10 days.

Keywords: Atomic Absorption Spectrophotometry (AAS), Meat, Fish, Mineral Content

INTRODUCTION

Meat is one of the most nutritious foods that humans can consume, particularly in terms of supplying high-quality protein (essential amino acids), minerals (especially iron) and essential vitamins (Lijalem *et al.,* 2015). In human nutrition, fish represents an important food ingredient due to its excellent organoleptic quality and its high content of proteins and lipids with superior biological value and digestibility degree. In some countries, fish constitutes the main source of food of animal origin (El-Rammouz *et al.,* 2013). In 2013, the average person consumed about 16 kilograms of pig meat; followed by 15 kilograms of poultry; 9 kilograms of beef/buffalo meat; 2 kilogram of mutton and goat; and only a fraction of other meat types (Ritchie and Roser, 2019). Global meat consumption increased by 58% over the last 20 years to 2018 to reach 360 million tonnes. Population growth accounted for 54% of this increase and per person consumption growth accounted for the remainder (Whitnall and Pitts, 2020). The total consumption of meat and fish at a global level is expected to increase by 15% between 2018 and 2027, while meat and fish consumption at a per capital level is to rise by only 3% in the mentioned period, according to a new report launched by OCED and the UN Food and Agriculture Organization (FAO) (Meat Commerce, 2020).

According to the Federal Government of Nigeria every year, its citizens consume 360,000 tonnes of beef, accounting for half of all West Africa. In per-capita terms, consumption is low when compared with advanced economies, but it is growing fast, and expected to quadruple by 2050 (Vanguard, 2019). Meat, fish and animal product are the fourth commonly consumed food group (88.9%) by households. It consumptions lags behind grains and flours (97.2%), oils and fat (96.8%) and vegetable (96.7%) (National Bureau of Statistics, 2016).

Encouraging, as this may sound, the quality of meat tends to be paramount than its consumption index. Report show that animals used to produce meat in the developing countries live under various harsh conditions often of poor feeding regime and grow slowly, yielding older animals for slaughter from which meat that is tough, less juicy and of a lower quality that differs considerably from those obtained in developing countries (Osadebamwen, 2015). Rearing animals in harsh environment and inadequate feeding mechanism has been shown to affect the quality of the meat especially their mineral content such as sodium, calcium, phosphorous, magnesium, chloride, potassium, iron, zinc and iodine (Fanuel et al., 2015).

Another factor is the preservation method after slaughter, freezing is a much-preferred technique to preserve fish and fish products for long period. It also has the advantage of minimizing microbial or enzymatic activity (Martino *et al.,* 1998). In Nigeria, Freezing method is the most widely used method of preservation, with fish such as tilapia, red pacus, river bream, pangassius, horse mackerel, sardine and croaker being among frozen items imported into the country (Nnodim, 2017).

In the local communities, consumers tend to buy frozen meat products in the market, not taking into cognisance the time the product must have been stored in the freezer, thereby impairing its quality. Yakasai *et al.,* (2020) reported that protein content in meat and fish reduced as storage time in a frozen state increased, there by leading to loss in protein value of the products. Most of the fish sold in Kaduna State are often frozen after been slaughtered or bought frozen from a local cold room to avoid spoilage. These frozen foods are often times stored for a period, depending on the capacity of the storage cabinets (cold room). There are instances of fish products being stored in a frozen state for more than 3 weeks due to poor patronage.

This research focuses on examining the mineral content of meat/fish stored over a period. This was initiated to determine the hypothesis that mineral content values in meat/fish tend to depreciate, as storage period increases. This research will also show if there is any relationship between pH and mineral content

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in fish/meat as storage period increases.

METHOD OF ANALYSIS

Sample Collection

Fresh cow meat, ram meat, goat meat, tilapia and catfish fish were bought at the four different major slaughtering markets (Central market, Mando fish farm, Kawo market, Barnawa fish pond) located within Kaduna metropolis in Kaduna North and Kaduna South local government areas of Kaduna State. The meat and fish samples (front, middle and rear) parts were bought in duplicates from the selected slaughter slab market and ponds in January; 2016. The meat and fish samples as well as the control were immediately stored in an insulated cooler at a temperature of -4^0 Celsius and transported to the laboratory for analysis and continual storage.

Sample Preparation

Ten (10) fresh fish samples of catfish and tilapia each were washed with tap water several times rinsed with distilled water and were cut into slices. The samples and the control were stored in a rubber zip seal and kept in a freezer under a freezing condition throughout the duration of the research. Samples were taken each from the front, rear and the middle of each fish, cut into pieces and mixed thoroughly to obtain a homogenized representative sample. The stored homogenized fish samples were taken for analysis at day 0, 3, 7, 10, and 30. The same procedures were also carried out for the meat samples as stated above.

Mineral Analysis

The homogenized meat samples (1 gm) was weighed using a weighing balance and transferred into a 50 cm^3 digestion tube, 20cm^3 of acid mixture H_2SO_4, HNO_3, HCl_4 (in the ratio of 2:1:1) was added to the sample and was digested on a hot plate until a clear colourless solution was observed. The digested sample was allowed to cool, filtered and made up to the mark with deionized water into a 50cm^3 volumetric flask. The samples were then analyzed for different mineral elements (Iron, Calcium and Magnesium) using the Atomic Absorption Spectrophotometer and Sodium and potassium were determined with a flame photometer Ayeloja *et al.,* 2014; Obany *et al.,* 2016.

RESULTS AND DISCUSION

The following results for the analysis of essential elements (minerals) of the meat samples are represented in Table 3.1 – 3.5 with concentrations statistically analysed using mean and standard deviations. The

Table 3.1: The pH readings and minerals level of Ram meat Samples

DAY	pH	MINERALS (mg/Kg)				
		Fe	Na	K	Mg	Ca
1	6.9	0.33	5.61	1.96	1.14	0.69
3	6.5	0.88	4.16	2.95	0.97	0.29
7	5.7	0.64	5.90	3.07	0.93	0.40
10	5.4	0.80	5.80	2.70	1.17	0.38
30	7.6	0.83	5.60	2.83	1.28	0.57
Mean	6.42±0.89	0.69±0.22	5.41±0.71	2.70±0.43	1.09±0.14	0.46±0.16

Table 3.2: The pH readings and minerals level of Cow meat Samples

DAY	pH	MINERALS (mg/Kg)				
		Fe	Na	K	Mg	Ca
1	6.5	0.34	7.90	2.67	1.11	0.49
3	6.2	0.70	5.87	2.28	0.77	0.30
7	6.2	0.87	5.82	2.54	0.83	0.37
10	6.5	1.36	4.56	2.42	0.83	0.20
30	8.0	2.27	5.48	2.56	1.10	0.33
Mean	6.68±0.75	1.10±0.74	5.92±1.22	2.49±0.14	0.90±0.28	0.33±0.10

Table 3.3: The pH readings and minerals level of Goat meat Samples

DAY	pH	MINERALS (mg/Kg)				
		Fe	Na	K	Mg	Ca
1	6.6	0.21	4.11	2.57	1.04	0.60
3	6.2	0.91	4.58	1.55	0.99	0.29
7	6.3	0.46	6.40	2.06	0.78	0.26
10	6.5	1.10	5.95	2.82	1.02	0.29
30	7.8	1.60	7.82	2.35	0.46	0.60
Mean	6.68±0.64	0.85±0.54	6.77±1.74	2.27±0.49	0.85±0.24	0.40±0.17

Table 3.4: The pH readings and minerals level of Catfish Samples

DAY	pH	MINERALS (mg/Kg)				
		Fe	Na	K	Mg	Ca
1	6.7	1.48	4.55	2.66	1.03	0.31
3	6.7	0.98	5.32	2.46	1.18	0.37
7	6.5	0.33	5.06	3.16	1.19	0.45
10	6.7	0.64	5.57	3.00	1.07	0.34
30	7.8	0.83	6.33	3.31	1.10	0.43
Mean	6.68±0.52	0.85±0.42	5.36±0.65	2.91±0.35	1.11±0.06	0.38±0.05

Table 3.5: The pH readings and minerals level of Tilapia Samples

DAY	pH	MINERALS (mg/Kg)				
		Fe	Na	K	Mg	Ca
1	6.7	2.52	6.14	3.14	0.85	0.44
3	6.8	0.47	7.20	2.26	1.80	0.38
7	6.6	0.44	6.49	2.75	1.18	0.69
10	6.9	0.64	6.80	2.87	1.30	0.81
30	7.5	1.72	6.31	2.50	1.65	0.87
Mean	6.9±0.35	1.15±0.92	6.58±0.42	2.70±0.33	1.35±0.37	0.63±0.21

It was observed that there was a gradual increase in pH values from day 10 to day 30 with storage time respectively for both fish and meat samples as shown in Table 3-1-3.5 but within the permissible recommended values as stated by Egyptian Organisation Standards (2005) and Food Safety Authority of Ireland (2015) for day 10 except for ram meat pH values. This observation is in agreement with Mazrouh (2015) who stated that such increase in pH values after the acidic condition have occurred is caused by enzymatic degradation of the fish and meat muscles and thus starts the continuous increase in the pH values as further chemical processes occur in the fish and meat muscles. The Egyptian Organisation Standards (2005) and the Food Safety Authority of Ireland (2015) recommended that fish and meat with a pH value of 5.8 - 6.8 is permissible for consumption and any pH value higher or lower than the recommended value should be prohibited.

Iron (Fe) is one of the key minerals present in meat, which plays a vital role in human health and its deficiency causes several hindrances in the normal functioning of human body, particularly disturbs child growth and development (Lozoff and Georgieff, 2006). Fe mineral values ranged from 0.33 – 88mg/Kg; cow meat values ranged from 0.34-2.27 mg/Kg; goat meat ranged from 0.21 – 1.60 mg/Kg; while catfish and tilapia ranged from 0.33-1.48 mg/Kg and 0.44-2.25 mg/Kg. It was observed that the Fe values fluctuated from Day 1 – Day 30 period of analysis. In all reported Fe values, the tilapia sample had the highest peak Fe values, followed by the cow meat value. Rabia *et al.,* (2018) reported higher Fe mineral values in ram meat at 0.99mg/100g. The World Health Organisation recommends universal supplementation with 2mg/kg/day of iron in children aged 6 to 23 months. These are for children whose diet does not include foods fortified with iron or who live in regions (such as developing countries), where anaemia prevalence is higher than 40%. For example, Nigeria prevalence value is above 60% in pregnancy and about 7.0% of the women are said to be severely anaemic (World Health Organization, 2001; Agan *et al.,* 2010). The Fe values in the meat and fish were below the Recommended Dietary Allowance for children and Adults and lower than the adequate intake of Fe recommenced, which ranged from 7mg – 11mg for children and adults; 27mg for pregnant women (Institute of Medicine, 2001).

Sodium (Na) controls fluid balance in our bodies and maintains blood volume and blood pressure. Eating too much sodium may raise blood pressure and cause fluids retention, which could lead to swelling of the legs and feet or other health issues. While limiting sodium in meal, a common target is to eat less than 2000 milligrams of sodium per day (UCSF, 2020). Na mineral values in ram meat ranged from 4.16 -5.90 mg/Kg; cow meat values ranged from 4.56-7.90 mg/Kg; goat meat ranged from 4.11-7.82 mg/Kg; while catfish and tilapia ranged from 4.55-6.33 mg/Kg and 6.14-7.20 mg/Kg. From these values, it can be observed that all meat/ fish Na values were within the same range but rather low when compared with Abulude, (2007) Na mean value of 622.6mg/100g for meat samples from giant rat, tullberg's rat, grass cutter, albino rat, tree squirrel, Cuban boa, python, cattle egret, pigeon bird and bat. Isa *et al* (2015) reported that Na values reduced as storage time increased from week 1 – week 6. Tilapia obtained from Tagwai and Shiroro reduced from 43.42-34.10mg/100g and 44.33 – 38.37mg/100g. While Na in catfish reduced from 46.11mg/100g – 38.37g/100g in Tagwai and 46.41-36.41g/100g in Shiroro, Niger State, Nigeria. The Sodium values reported by Abulude (2007) and Isa *et al. (*2015) showed increased Na values in both meat and fish samples, suggesting that the Na values in the analyzed meat/fish samples were low, depicting poor feeding mechanism to the animals. The mineral content of Potassium (K) in the ram meat ranged from 1.96-3.07mg/Kg, cow meat ranged from 2.28-2.67 mg/Kg, goat meat ranged from 1.55-2.82 mg/Kg, while the catfish and tilapia ranged from 2.46-3.31 mg/Kg and 2.50-3.14 mg/Kg. the K content in all the samples analysed was low. Job *et al.,* (2015) reported K content of 17.1mg/100g and 11.9mg/100 in wild and cultured tilapia fish samples, which were below the recommended limits ranging from 19-502mg/100g as stated by FAO/USDA, (2010), suggesting environmental factors as the limiting barrier. Ajai *et al.,* (2019) reported high mean K content of 452.26±41.03 mg/100g in beef obtained from Niger state. K mineral content in the analyzed meat/fish samples were lower than the recommended level and as compared to reports by other authors. Increasing potassium intake can decrease blood pressure in adults with hypertension (Newberry *et al.,* 2018).

Mg content in ram meat ranged from 0.93 – 1.28mg/kg, cow meat ranged from 0.77-1.11mg/kg, goat meat ranged from 0.46-1.04 mg/kg, catfish ranged 1.03-1.19 and tilapia ranged from 0.85-1.80 mg/kg, showing low presence of the mineral in the meat sample. The FAO/USDA, (2010) recommends Mg mineral content ranging from 4.5-452mg/100g. Job *et al.,* (2015) also reported low Mg content of 2.7mg/100g in tilapia samples. Obany *et al.,* (2016) reported similar low Mg values in farmed and wild Catfish samples with mean values of 2.65±0.36mg/Kg and 2.559±0.38mg/Kg. However, Fanuei *et al.,* (2017) reported Mg values in Catfish obtained from three different ecosystems (Lake Kairba, Lake Manyame and Lake Chivero) in Southern and East Africa with values of 24.17mg/100g, 18.83mg/100g and 46.00mg/100g. Some of the main function of magnesium in the body include keeping intracellular sodium and calcium low and potassium high, cellular and tissue integrity, mitochondrial oxidative phosphorylation (ATP production and activation), and DNA, RNA and protein synthesis and integrity (Wacker and Parisi, 1968).

Catfish samples had a Ca value of 0.31-0.45mg/kg, ram meat value from 0.29-0.69 mg/kg, cow meat value from 0.20-0.49 mg/kg and tilapia values ranging from 0.38-0.87 mg/kg within the freezing period of Day 1- Day 30. Amongst the reported values, the tilapia had the highest Ca values amongst the samples, although they are within the same range. Adelakun *et al.,* (2017) reported Catfish Ca values of 1.05±0.19mg/g and 2.09±0.93mg/g. Tsegay *et al.,* (2016) reported high Ca values in Female and Male Nile tilapia obtained from Hashenge and Tekeze Reservoir with mean values of 628.65±5.78mg/Kg and 629.05±2.36, 673.38±0.896mg/Kg and 673.29±1.91mg/Kg. The reported Ca values in the fish and meat samples were below the recommend Ca values ranging from 5.00 – 502.00mg/100g as stated by FAO/WHO, (2011).

Conclusion

Meat and fish are good sources of minerals needed for proper functioning of the human being. Past and recent scholarly articles have shown that different meat from animals and fishes have various levels of minerals in them. These minerals most times are above, either within or below the recommended limits, depending on various factors such as feeding mechanisms, environmental factors, species of animals and methods of cultivations. The research showed that meat/fishes frozen from week 1- week 6 retain minerals needed by the body. Though below the recommended minerals limits by FAO/WHO/USDA, which could be as a results of various factors stated above. All the fish and meat samples in this study were unacceptable in the 30th day due to increasing pH values (enzymatic degradation), which catalyses the rapid decomposition of the fish and meat.

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