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Health Risk Assessment of Heavy Metals Concentrations in Processed Canned Meat in Bayelsa State, Nigeria

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Abstract

Meat forms a considerable component diet, providing essential nutrients to large number of people around the world. The chemical composition of meat depends on the kind, degree and quality in feeding (feeds and water); therefore, the potent consequences of feeding livestocks with polluted feeds and water challenges the wholesomeness of the meat by exposing man to array of toxic chemicals via bioaccumulation and biomagnifications. The used of canning to prolong meat shelf life, easy transportation, distributions and uses, has further questioned the quality of canned meat products. This survey determines the content of Cadmium, Chromium, Copper, Iron, Tin, Lead, Mercury, Manganese, Nickel and Zinc in canned meat by means of ICP-MS apparatus and mercury analyzer; compared with recommended standards for heavy metals concentrations. Results from this survey shows that Sn, Hg and Fe were below recommended limit in all canned meat products; Cd is also within limits except in Costa product; Cu is within limits except in Exerter and Costa products; unfortunately, Cr, Pb, Mn, Ni and Zn were above recommended limits in all the products. At 95%, the differences concerning heavy metals and various canned meat products were statistically significant. The study, therefore, recommended that the daily ingestion of the above canned products should be limited to avert possible adverse carcinogenic effects in future.

Keywords: Heavy Metals in Canned Food, Canned Meat, Canned Food Contamination, Food Toxicity and MCE (SRLs) (mg/kg).

Introduction

Meat forms a considerable component diet, providing essential nutrients to large number of people around the world (Ebuete *et. al.*, 2020). The consumption of meat products is on the increased so also the purchasing demand due to population increased and changing lifestyle with a direct call for processed canned meat.

The name "canned meat" according to Ami *et.al.* (2017) is the processed meat product enclosed in metal cans, glass jars, or plastic containers, to ensure long shelf life through the process of pasteurization and airtightness of the packaging, that protect against access of air and contaminants. Importantly, canned products have the advantage of longer shelf life (1-30yrs) (Lewis, 2015); easy transportation and distributions, budget friendly and easy uses, freshness, sustainability and prestige. No wonder, canning has become the defining characteristics of a modern life (Kemi *et.al.*, 2018).

In spite of the preserved taste, nutritive values and technological processes; can food also contain chemical contaminants? Via chemical hazards in food additives (sodium nitrate or potassium nitrate), environmental contaminants (mercury, dioxins and residues of heavy metals), pesticides and veterinary drugs (Kowalska, Pankiewicz & Kowalski, 2020). Other sources of contamination arising from incorrect technological processing or incorrect packaging (Buculei *et. al.*, 2014; Amit *et. al.*, 2017); capable of causing indentation and percussions which are major causes of foodborne Clostridium botulinum disease and change of food's sensory.

Canning is a preservative process of subjecting foods in jars or cans to a specified temperature that destroys microorganisms and inactivates enzymes that preserve products for safety and quality. Regrettably, the process involved the use of metals (steel, aluminum, tin and chromium) and alloys as food contact materials (cans) that provides good mechanical properties and gives a glossy appearance to protect against corrosion, e.g. as process equipment in the food industry, containers and as household utensils capable of releasing metal ions (heavy metals) both the main components and foreseen impurities that makes them a potential source of food contamination (Cederberg *et. al.*, 2015).

These heavy metals (elements with an atomic density greater than 6g/cm^3 (Ebuete *et.al.*, 2019) are major threat to the entire ecological community even down to the food chain; thus, they have become an international environmental and public health concerned (Muncke, 2014; Mustafa, 2015). However, metals ions like Copper (Cu), Zinc (Zn), Cobalt (Co), Manganese (Mn), Nickel (Ni) and Iron are inorganic biochemical elements required in maintaining and regulating normal physiological processes in human body at low concentration; others like Lead (Pb); Cadmium (Cd); Mercury (Hg); Chromium (III) (Cr); Cadmium, Nikel and Arsenic (As) are relatively very toxic even at low concentration hence, they are listed among global contaminants and most hazardous inorganic of the EPA Hazardous Substance Priority (UNEP, ERCE, UNESCO, 2008; Markmanuel & Horsefall, 2016; Guta, 2018).

Rodriguez-Mendivil *et. al. (*2019) opened that the main route of heavy metal exposure in human is through the consumption of contaminated food or water, resulting in negative health effects. In recent years, concern about food quality has increased, particularly in foods at risk of containing toxic elements and compounds that represent risk to human health, such as persistent organic pollutants (POPs) and heavy metals (Markmanuel, Amos-Tautua & Songca, 2022).

Statement of Problem

Food safety is gaining prominent among global food actors, as several human biomonitoring studies like Dallatu *et.al.* (2013) AL-Rajhi (2014); Hartle, Navas-Acien and Lawrence (2016); Dubey, Agnihotri and Shukla (2016); Massadeh *et.al.* (2018), Kemi *et.al.*, (2018); Erhunmwunse, Tongo and Ezemonye (2020); Leite, Lima and Nascimento (2022);

Wang, *et.al.* (2022) is pointing towards the potential toxicological effects of heavy metals on the reproductive system, cancer, neurological issues, cardiovascular diseases, nervous and immune systems disruption due to the consumption of canned food. This has made canned meat hygiene gained immense prominence as a matter of utmost public health concern especially to the meat consumer, which called for meat safety and quality supply keeping in view the place of the "4Ps" (Premises, Personnel, Processes and Products).
The principal of Hazard Analysis Critical Control Points (HACCP) is to ensure the migration of substances (heavy metals) from food contact materials to food is not above toxicological reference values to endanger the human health of the consumer or unacceptably alter the composition of the food or its organoleptic characteristics which has not been successfully achieved (Centers for Diseases Control and Prevention, 2022); and the implementation of good rules and regulations by FAO/WHO and other regulatory agencies has not totally abrogated the presence of contaminants due to environmental impact of the contamination particularly in our daily consumption.

Objectives of the Study

This study therefore, aimed to perform quantitative determination of heavy metals (Pb, Cd, Sn, Cr, Mn, Fe, Zn and Ni) in imported brand of processed canned Beef, Chicken and Turkey and assess the health risk via consumption by local residence in Bayelsa state, Nigeria.

Materials and Methods

Study Area

The study was conducted in Yenagoa, the capital city of Bayelsa State, Nigeria. Yenagoa City is located at the southern part of Nigeria at a coordinates 4°55'29''N and 6°15'51''E, with an area of 706km².

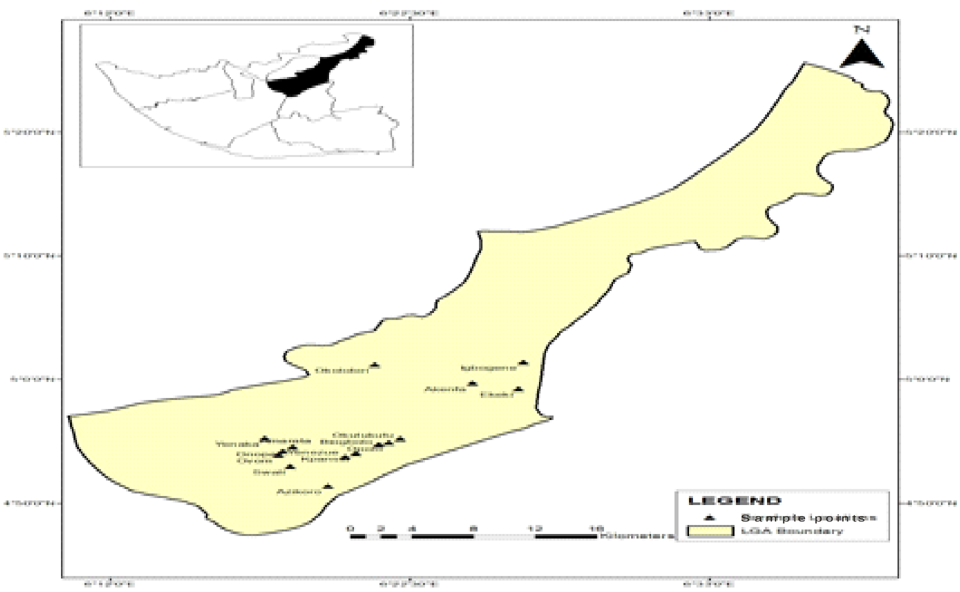

Fig.1. Map of Bayelsa State Showing Yenagoa

Source: Researcher, 2023.

Experimental Material and Sample Preparation

Research material consisted of Brazilians products like the Exeter Corn Beef (340g) and Napa Valley Corned Beef (340g); Zwan Chicken (200g) Netherland products and Zwan Turkey (200g) Turkey products (Table 1). The canned meats (4 assortments from 3 kinds of meat: Beef, Turkey and Chicken) is purchased from the hypermarket in Yenagoa City (year of production 2021). The content of every cane was homogenized. Next, the samples were frozen (−20°C), lyophilized in a Labconco freeze dryer (Model 64132, Kansas City, MO, USA) and stored in a desiccator for further use.

Measurement of Water Content and Metal Determination

Water content in fresh and freeze-dried samples was determined with the use of a moisture analyzer (Radwag WPS50SW) after drying samples at 100°C. Result was the average of three measurements.

Determination of Heavy Metals (Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn, Ni and Hg)

Three subsamples derived from the samples taken from every cane have been analyzed: about 0.5000g of sample material was weighed directly into a Teflon vessel, 10mL of 65% HNO_3 was added (Suprapur grade, Merck, Germany), and microwave mineralization was performed (Mars 5, CEM Corporation, USA). A blank sample containing only the reagents was attached to every mineralization batch following methods described by Kowalska, Pankiewicz and Kowalski (2020). The microwave mineralization was performed stepwise at 400W and 363 K (4 min), at 800W and 393K (5 min) and at 1600W and 483K (6 min). The cooled digested solution was then diluted to 50mL using high purity deionized water.

ICP-MS Measurements

For determination of Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn, Ni and Hg in the samples, the inductively coupled plasma mass spectrometer ICP-MS 820- MS (Varian, Mulgrave, Australia) with quadrupole mass analyzer was used. The instrumental conditions for trace elements determination by ICP-MS were as follows: plasma: argon plasma; plasma flow: 18 L min−1; auxiliary flow: 1.8 L·min−1; stealth gas flow: 0.12 L·min−1; nebulizer flow: 0.95 L·min−1; sampling depth: 6 mm; RF power: 1.35 kW; pump rate: 0.1 Hz; stabilization delay:35s; first extraction lens:5V; second extraction lens:190V; third extraction lens:225V; corner lens:200V; left mirror lens:39V; right mirror lens:34V; bottom mirror lens:36V; entrance lens:1.00V; fringe bias: −2.90V; entrance plate: −39V. Calibration curve for each element was prepared using the highest purity standard solutions (1000mg·L−1, 99.999%) from Ultra Scientific. The calibration standards for ICP-MS analysis were prepared by diluting the solutions with 1% HNO_3. The results were expressed in mg·kg−1 of fresh matter. The analytical quality was controlled by means of measurement of a blind sample and a double sample.

Determination of Mercury (Hg) Concentration

Mercury was determined independently using non-flame atomic spectrometry absorption technique (Mercury Analyzer AMA 254, Altec, Czech Republic) according to previously described method (Kowalski & Kucharski, 2007; Kowalska, Pankiewicz & Kowalski, 2020). Correct operation of the apparatus was controlled regularly by calibration of standard mercury solutions—NIST-traceable Hg standard solution (Accu Trace Single Element Standard; Accu Standard Inc., New Haven, CT, USA) (Ociepa-Kubicka & Ociepa, 2012).

Statistical Analysis

Data were analyzed using Two-Ways ANOVA to test for statistical difference among canned food products and the concentrations of heavy metals at %5 limits (P<0.005).

Results and Discussion

Table 1. Triplicate Laboratory Analysis of Heavy metals in Canned Meat

ELEMENTS	BRANDS OF CANNED MEAT SAMPLES				
	EXETER CORN BEEF	COSTA CORNED BEEF	CORNED BEEF (NAPA)	ZWAN CHICKEN LUNCHEON MEAT	ZWAN TURKEY LUNCHEON MEAT
Cadmium (Cd) 1. 2. 3.	0.005 0.005 0.002	0.011 0.012 0.011	0.002 0.003 0.001	0.008 0.008 0.007	0.002 0.003 0.002
Chromium (Cr)	3.093 3.092 0.092	1.644 1.643 1.643	5.432 5.431 5.431	2.815 2.814 2.813	1.472 1.470 1.471
Copper (Cu)	7.133 7.134 7.132	4.825 4.824 4.823	3.549 3.548 3.547	2.052 2.052 2.050	2.939 2.938 2.938
Iron (Fe)	14.339 14.342 14.340	8.479 8.479 8.480	9.539 9.538 9.539	5.031 5.030 5.030	7.499 7.498 7.497
Lead (Pb)	2.486 2.488 2.487	1.890 1.891 1.891	1.724 1.723 1.723	2.039 2.038 2.039	1.303 1.302 1.302
Manganese (mn)	19.018 19.016 19.018	11.626 11.625 11.624	15.184 15.183 15.182	13.056 13.055 13.054	10.433 10.432 10.434
Mercury (Hg)	0.005 0.004 0.003	0.002 0.003 0.001	BDL BDL BDL	BDL BDL BDL	0.002 0.001 0.001
Nickel (Ni)	3.489 3.488 3.487	1.199 1.198 1.197	5.127 5.126 5.125	2.561 2.562 2.560	1.915 1.914 1.913

Tin (Sn)	9.207 9.208 9.206	6.137 6.138 6.139	4.739 4.741 4.740	2.546 2.547 2.546	5.834 5.835 5.833
Zinc (Zn)	23.017 23.016 23.018	17.624 17.623 17.622	21.029 21.027 21.028	24.923 24.924 24.922	15.520 15.519 15.518

Table 2. Mean Heavy metals concentrations in Canned Meat against Recommended Limits

ELEMENTS	SAMPLES					
	EXETER CORN BEEF	COSTA CORNED BEEF	CORNED BEEF (NAPA)	ZWAN CHICKEN LUNCHEON	ZWAN TURKEY LUNCHEON	MCE (SRLs)
Cadmium (Cd)	0.00413	0.01056	0.00148	0.00753	0.00169	0.005
Chromium (Cr)	3.09214	1.64293	5.43136	2.81375	1.47054	0.250
Copper (Cu)	7.13251	4.82349	3.54824	2.05082	2.93852	4
Iron (Fe)	14.34042	8.47861	9.53751	5.03017	7.49835	40
Lead (Pb)	2.48742	1.89126	1.72304	2.03849	1.30174	0.010
Manganese (Mn)	19.01738	11.62524	15.18317	13.05482	10.43284	1.8
Mercury (Hg)	0.00354	0.00193	BDL	BDL	0.00116	0.003
Nickel (Ni)	3.48769	1.19834	5.12572	2.56084	1.91364	0.14
Tin (Sn)	9.20718	6.13782	4.73945	2.54629	5.83371	200
Zinc (Zn)	23.01718	17.62313	21.02834	24.92312	15.51910	5

Source: Researcher, 2023. Council of Europe Specific Release limits MCE(SRLs) (mg/kg)

Heavy Metal Assessment

Toxic trace elements in canned foods may occur because of contamination of the food commodity, through migration from the packaging material, technological defects and human mishandling (Dave & Ghaly, 2011). The inner side of metallic food packaging composed of tinplate (tin-coated steel), chromium coated steel, or aluminum; mostly coated on with a resin to protect food from coming in contact with the metal. However, when the metal is exposed to the food as a result of damage of the coating, corrosion is accelerated and elements such as tin (Sn), iron (Fe), cadmium (Cd) and lead (Pb) may be released, increasing their levels in the food (Kassouf *et.al.*, 2013; Fiamegos *et.al.*, 2016).

Cadmium (Cd)

Cadmium is a common contaminant found in most human foodstuffs due to the high plants' transfer factor properties, which is the primary pathway to human through consumptions. The tolerable daily intake of Cadmium is 62µg/day per 70kg of body weight. On the contrary, Cadmium (Cd) toxicity affects tissues such as appetite and pain centers (in the brain), brain, heart and blood vessels, kidney and lungs. The Cd concentration in the current study revealed a mean of 0.004; 0.011; 0.002; 0.008 and 0.002 for Exeter, Costa, Napa, Zwan chicken and Zwan Turkey respectively (table 2). Cd concentrations in Costa Corned beef and Zwan Chicken represents higher above limits recommended by Council of Europe Specific Release limits (SRLs) (0.005mg/kg) which can be attributed to the handling, transportation and processing of meats, from farm to fork or from contact between food and metals used in the canning processes. Bakircioglu, Kurtulus and Ucar (2011) on the other hand also declared that the addition of spices during production of canned meat might be the main reason for contamination with Cd, since spices could contain Cd concentrations up to 200 ng/g; outstanding opinion to this study.

The results is in consistent with the reports of Leite *et.al*., (2022) of 0.00002- 0.002 mg/kg; Hussein, Rathi and Kadhim (2021) 0.1214-0.3078 mg/kg in chicken and 0.1284 – 0.3017 mg/kg in beef meats; Kowalska, pankiewicz and Kowalski (2020) 0.005mg/kg; Oloruntoba and Nathaniel (2019) 0.500- 57.00 respectively for Chicken kidney and liver. Khalafalla (2016) reported 0.057 and 0.053 for canned chicken luncheon and canned beef luncheon respectively; Nasser (2015) 0.14-0.61 mg/kg; Ei-Salam *et. al.* (2013)1.15mg/kg; Hamasalim and Mohammed (2013) 0.001-0.27; Al-Zuhairi, Farhan and Ahemd (2015) 0.0579-0.6801; Makki (2019); Buculei *et.al.* (2014); Ihedioha and Okoye (2012) and Iwegbue (2011) 0.02–0.37;

Lead (Pb)

Lead is a metabolic poison and a neurotoxin that binds to essential enzymes, inactivates several other cellular components in human. It is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular diseases in adults (Khalafalla *et.al.*, 2016). The current study showed Pb concentration variation with values range of 1.302 - 2.487mg/kg, in an order of EXETER>ZWAN Chicken>COSTA> NAPA>ZWAN Turkey; which is above the limits accepted by the **MCE (SRLs)** of 0.01mg/kg (table 2). This may be attributed to the used of lead solder with a sheet steel cans enclosed with seams, enamel or vinyl protective coatings. Similar, studies such as Hussein, Rathi and Kadhim (2021) reported mean Pb concentrations range of 0.0519- 0.2454mg/kg in chicken and 0.0217-0.2070 in beef meat; Stojanovic *et.al.* (2021) reported 8.00µg/kg; Enuneku *et.al.* (2019) reported 0.01mg/kg; 0.03mg/kg and 0.02mg/kg in NAPA, ZWAN and KIRLAND respectively. Khalafalla *et.al.* (2016) 0.330mg/kg and 0.244 mg/kg with canned chicken luncheon and canned beef luncheon respectively; Alzuhairi *et al*. (2015) 0.0953 mg/kg with chicken; Hamasalim and Mohammed (2013)1.19, 1.02, 1.00, 0.52µg/g, in four canned chicken luncheon; Iwegbue (2011) 50.001–1.5mg/kg;

Akan *et al*. (2010) 0.25mg/kg in beef; Demirezen and Uruc (2006) 0.18-0.28mg/kg in beef; Ojezele *et.al.* (2021)1.76mg/kg and 40mg/kg in hot dog sample and mushroom sample.

Chromium (Cr)

Chromium is an essential element in human body, as it boosts the enhancement of inulin and the transformation of proteins (component of Trypsin) and lipids (Cholesterol). The Adequate Intake (AI) for Cr in men is 35µg/day and 25µg/day for women (age 19 -50 years). However, at +6 state of oxidation compounds (chromates); chromium show a strong mutagenic and teratogenic effects; correlated with lung cancer in humans and kidney damage in animals (Seyed *et al*., 2015). The report in this study recorded 3.09; 1.64; 5.43; 2.81 and 1.47mg/kg for Exeter Corn Beef, Costa Corn beef, Corned Beef (Napa), Zwan Chicken and Zwan Turkey respectively in an order of NAPA>Exeter>ZWAN Chicken>Costa>ZWAN Turkey which is above the recommended limits by the Council of Europe Specific Release limits (SRLs) of 0.25mg/kg (table 2). The highest concentration recorded is with Corned Beef (Napa) (table 1); which may be linked to the methods of food preparation and storage systems. Korkmaz, *et.al.* (2017) submitted that food products stored in metal containers or cans has the chances of increasing the content of chromium. Similarly, Ojezele *et.al.* (2021) 1.74-2.55 mg/kg in canned mushroom; Kowalska, Pankiewicz and Kowalski (2020) 0.02-0.24mg/kg; Hamasalim and Mohammed (2013) 0.10-0.4mg/kg. Samira and Weam (2012) made lesser values with a range of 0.04-0.06 mg/kg in chicken; Iwegbue (2011) 50.04–0.75; Al-Zuhairi, Farhan, & Ahemd (2015) 0.0053-0.7892ppm; AL-Rajhi (2014) 0.0008-0.0047 mgkg-1.

Copper (Cu)

Copper is a reddish metal that occurs naturally in rock, soil, water, sediment, and air. It also occurs naturally in all plants and animals through ingestions, drinking and respiration. It is an essential element for all known living organisms including humans and other animals at low levels of intake; thus, the Recommended Dietary Allowance (RDA) for adult 19+ is 900µg/day while 200-700µg/day is for younger age. However, intentionally high intakes of copper can cause liver and kidney damage and even death (ATSDR, 2005). The values of Cu recorded in this study range from 2.05mg/kg with Zwan chicken to 7.13mg/kg with Exeter corn beef in an order of EXETER> COSTA>NAPA>ZWAN Turkey ZWAN Chicken (table 2). All the products were within the limits accepted by the **MCE (SRLs)** of 4mg/kg except for products of Exeter corn beef (7.13mg/kg) and Costa Corned Beef (4.82mg/kg) which could be traced to meat contamination at farm or folk. Similar results were reported by Altıntığ *et al*., (2016) in canned mushrooms at a range of 40.8-71.89mg/kg; Ojezele *et.al.* (2021) reported a range of 0.01-0.41mg/kg. AL-Rajhi (2014) reported a range of 0.0001-0.0017kg-1; Areej, Angham and Adem (2012) a range of 0.001-0.1ppm; Iwegbue (2011) reported 1.1–2.4 for Cu; Orisakwe *et,al. (*2009) a ranged of 0.04 - 3.55 mg/L for canned beverage with a mean of 14.57mg.

Nickel (Ni)

Nickel is a ubiquitous trace element and the commonest cause of metal allergy among human. It occurs in soil, water, air and biosphere naturally. At low intake, Nickel is good for the management of Nickel Eczema, Nickel Dermatitis, involved in lipid metabolism and increases hormonal activities (Zdrojewicz, Ppopowicz & Winiarski, 2016). The dietary intake of Ni per day remained 69-162µg for adult of 18+ and 24-50µg/day for younger individual; however, at higher doses it stirs up serious reactions like erythema multiforme, Vasculitis and chronic Urticaria (Sharma, 2013); kidney diseases, lung fibrosis, nasal cancer and reduce the levels of other elements in the organism, such as magnesium, manganese and zinc. Contrarily, also its deficit inhibits growth and causes a lowering of the level of haemoglobin in blood as well as changes in the epidermis and disturbance in the pigmentation (Areej, Adem & Angham, 2012). Deficit in Ni element impairs also the function of the liver; abnormal cellular morphology, oxidative metabolism, and increases and decreases in lipid levels. The current study revealed Nickel concentration of 1.914mg/kg with Zwan turkey to 5.126mg/kg with NAPA Corned Beef in an order of NAPA>EXETER>ZWAN Chicken>ZWAN Turkey>COSTA. All the products were above the recommended accepted limits of 0.14mg/kg by the **MCE (SRLs)** (table 2); which can be attributed to the product processing processes and handling**.** Similarly**,** Altıntığ *et al*., (2016) recorded Nickel range of 3.49-3.59mg/kg, Ojezele *et. al.* (2021) reported 0.55±0.22mg/kg and 0.86±0.17 mg/kg in red kidney (RK) and hot dog (HD) respectively; Iwegbue (2011) reported 0.8–5.9mg/kg for Ni.

Zinc (Zn)

Zinc is an essential nutrient found in the human body, plants and other animals, that helps boost immune system and metabolism functions at low concentrations (Hennigar *et.al.*, 2018). It is therefore, recommended that 8mg/day for women and 11mg/day is needed for normal human metabolisms. However, higher doses of zinc can lead to vomiting, headaches, diarrhea and exhaustion. Records shows that zinc interferes with medications such as antibiotics, nonsteroidal and anti-inflammatory drugs (Marriott, *et.al.*, 2020). The concentration of Zn in this study range between 15.52-24.92mg/kg, with the highest concentrations found with Zwan Chicken luncheon. The concentration flows in the order of ZWAN Chicken> EXETER>NAPA>COSTA>ZWAN Turkey. The reported results in this study were above the limits accepted by the **MCE (SRLs)** of 5mg/kg (table 2) which is attributed to the presents of ZnO nanoparticles in the lining of the canned food for antimicrobial activities and the staining of sulfur-producing foods. This may negatively decrease nutrient absorption in digestion as well as bump up the levels of zinc in the food to 100times the daily allowance. Similar studies such as Ojezele *et.al.* (2021) Reported the range of of 0.0 - 1.34 mg/L for the canned beverages; AL-Rajhi (2014) reported 0.0120 for Zn; Hamasalim and Mohammed (2013) reported Zn range of 0.015-3.16mg/kg; Al-Thagafi, Arida and Hassan (2014) reported 24.14-26.76mg/kg; Areej, Angham and Adem (2012) reported a range of 0.0001-0007ppm, Iwegbue (2011) reported 1.1–8.0mg/kg.

Mangeness (Mn)

Manganese is a component of the antioxidant enzyme superoxide dismutase (SOD), which help fight free redicals, help form connective tissue, bones, blood clotting factors and sex hormones (Unanimous, 2023). It also plays role in fat and carbohydrate metabolism, calcium absorption, blood sugar regulation and necessary for normal brain and nerve functions at moderate dose. The recommended Dietary Allowance (RDA) of Mn for age 19+ is 2.3mg/day and 1.8mg/day for man and women respectively. Higher concentration of manganese in the body is reported to be associated with Neurological disorders similar to Parkinson's disease; a cause for poor cognitive performance in schoolchildren (Daroff, 2012). The concentration of Mn in the current study is 19.017 (Exeter); 11.625mg/kg (Costa); 15.183mg/kg (Napa); 13.055mg/kg (Zwan Chicken) and 10.433mg/kg (zwan Turkey). Mn concentrations is in the order of EXETER>NAPA> ZWAN Chicken> COSTA>ZWAN Turkey (table 2). All the products were above the limits accepted by the **MCE (SRLs)** of 1.8mg/kg; which can be attributed to meat food source contamination and handling. Similarly, Iwegbue (2011) reported 50.04–0.57mg/kg for Mn, AL-Rajhi (2014) reported 0.0029mg/kg for Mn; Oloruntoba & Nathaniel (2019) reported zinc concentration of 47.75mg/kg in Kidney and 119.5mg/kg for Liver. AL-Rajhi (2014) reported a range of 0.0025-0.0308 mgkg-1 with an average value of 0.0120mg kg-1 in chicken.

Mercury (Hg)

An acute Hg poisoning results in lung damage, while chronic exposure is characterized by neurological and psychological disorders such as tremors, changes in personality, restlessness, anxiety, sleep disturbance and depression, and irreversible kidney damage even after exposure cessation (Khalafalla *et al.*, 2016). The provisional tolerable weekly intake (PTWI) for inorganic mercury is 4µg·kg−1 of body mass and for the organic form, methylmercury, 1.6 µg·kg−1 of body mass. The concentration of mercury in this survey is 0.00354 (EXETER), 0.00193 (COSTA Corned Beef) BDL (NAPA Corned Beef), BDL (ZWAN Chicken Luncheon) and 0.00116 (ZWAN Turkey Luncheon). The concentration of Hg is in an order of EXETER> COSTA>ZWAN Turkey NAPA and ZWAN Chicken (table 2). All the products were within the limits accepted by the MCE (SRLs) of 0.003mg/kg. In a related studies Stojanovic *et.al.* (2021) reported 15.04µg/kg; Khalafalla *et. al.* (2016) reported 0.387 and 0.450mg/kg in canned chicken luncheon and canned beef luncheon respectively; Areej, Angham and Adem (2012) reported Hg of 0.001-2ppm in canned meat.

Tin (Sn)

The Codex Alimentarius Commission considered Tin to be a priority contaminant; which always finds its way into food chain through natural resources, environmental pollution, packaging material or the use of pesticides. The study reported 9.207mg/kg; 6.138mg/kg, 4.740mg/kg, 2.546mg/kg, 5.834mg/kg for EXETER Corn Beef, COSTA Corned Beef, NAPA, ZWAN Chicken and ZWAN Turkey respectively (table 1), in an order of EXETER>COSTA>NAPA>ZWAN Chicken>ZWAN Turkey. The recorded values were above

the limits accepted by the **MCE (SRLs)** of 200mg/kg (table 2). The dissolution of the tin plates introduced tin into canned foods at low pH, high temperature and exposure to air especially the stannous fluoride and chloride. Interestingly, a 200-300ppm concentration of Sn in food is tolerated but an excess dose leads to vomiting and diarrhea, skin irritation, headaches and facial disorders. The recommended dietary allowance for Sn is 0.3mg/day. Meat product contaminations at farm and folk are premium while meat processing and packaging is also a caused for the high values recorded. Kemi *et. al.* (2018) reported that BPA present in certain food contact materials is used in the production of polycarbonate and epoxy-phenolic resins, which can leach, seep into food pending the type of food or liquid, the temperature and the heating time to caused cancer, premature births; feminization of male offspring, activates human pregnane X receptor. (*Ibid*, 2018). Similarly, Khalafalla *et. al.* (2016) reported 2.061, 2.308, 0.755 and 1.997 mg/kg for canned chicken luncheon and canned beef luncheon respectively.
Mean of zinc is 5.31mg

Iron (Fe)

The Recommended Dietary Allowance (RDA) of Fe is 8.7mg for male and 14.8mg for female of 18+ years. EXETER Corn Beef (14.34042mg/kg); COSTA Corned Beef (8.47861mg/kg); NAPA Corned Beef (9.53751mg/kg); ZWAN Chicken Luncheon (5.03017mg/kg); ZWAN Turkey Luncheon (7.49835mg/kg) (table 1). The recorded values were within the tolerable limits accepted by the **MCE (SRLs)** of 40mg/kg but flows in this order EXETER Corn Beef>NAPA Corned Beef>COSTA Corned Beef>ZWAN Turkey Luncheon>ZWAN Chicken Luncheon (table 2). Similar results were presented by Leite et al. (2022) presenting a range of 1.466-3.507mg/kg; Iwegbue (2011) reported a range of 13.8 to 28.8mg kg^{-1} in various brands of canned beef while AL-Rajhi (2014) reported minimum far lesser values of 0.0197 for Fe.

Table 3. Two-Ways Anova Table

Source	SS	d.f`	M.S	*F*-ratio	%5 F-limits
B/W Heavy Metals	3773.39	9	419.266	8.963	9(36) = 2.093
B/W Canned Products	1732.97	4	433.24	9.262	4(36) = 2.65
Error	1683.92	36	46.776		

Source: Researcher, 2023.

From the statistical table, the differences concerning heavy metals is statistically significant as the cal. *F*-ratio value of 8.963 by interpolation method is greater than table value of 2.093; this is also applicable to the differences concerning difference canned food products (9.262>2.65) (table 2).

Conclusions and Summary

Food of animal origin provides important nutrients (protein, zinc, iron, selenium, vitamins and phosphorus) that constituted a well-balanced diet. The meat food industry employs numerous technologies such as canning to prolong shelf life, ease distribution and preserved quality. Unfortunately, the meat canning process has raised public health concerned to end user on the safety and quality of the products due to the exposure of man to toxic elements (heavy metals). Different countries have sets guidelines and established agencies that will protect human from the potent hazards caused by these chemicals. In Nigeria NAFDAC (National Agency for Food and Drugs Administration Control); SON (Standard Organization of Nigeria) among other food agencies were established to render services (product registration and regulation, perform clinical trial, issue licenses and inspects ports) that will promote health with appreciable results over years of operation. Interestingly, most imported canned meat may have to find its way into the country wholesomely but the environmental factors, handling processes, distributions and storing might have impaired with the quality. Therefore, there is need to assessed heavy metal concentrations in imported canned meat to determine health risk associated with the ingestion of these products using models.

The determination of canned meat contents for Cadmium, Chromium, Copper, Iron, Tin, Lead, Mercury, Manganese, Nickel and Zinc meat by means of ICP-MS apparatus and mercury analyzer and to compared with recommended standards for heavy metals concentrations. Results shows that the concentrations of Sn, Hg and Fe were below recommended limits (200, 0.003 and 40) in all canned meat products; Cd is also within recommended safe limits except in Costa product (0.01056>0.005); Cu is also within recommended safe limits except in Exeter (7.13251>4) and Costa (4.82349>4) products. Unfortunately, the concentrations of Cr, Pb, Mn, Ni and Zn were above recommended limits in all the products. These can be considered due to the migrations of metal ions from packaging material into meat food products. On the other hand, the contamination of meat products right from farm to folk is also a factor to considered; while the addition of spices to canned meat and soldering process of cans has added considerable number of heavy metals to canned meat and the contamination caused by handling, transportation, processing must never be under turned. Statistically, at the 0.005 degree of freedom, the difference concerning the concentrations of heavy metals among different canned meat is statistically significant and the difference concerning the concentrations of various canned meat products were significant.

Recommendations

It is therefore, recommended that:

- Daily ingestion of the above canned products should be limited to avert possible adverse carcinogenic effects in future.
- An in-house control based on a declaration of compliance, DoC, and supporting documentation by the producers and importers are important prerequisites to limit this contamination to detect the how, when, where and why in the contaminated canned food.

- Food regulatory body should ensure production compliance with the universal legislation.
- Regular monitoring of imported canned food should be undertaken at an intervals by the receiving country(s).

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