DISCOVERY

**To Cite:**
Markmanuel DP, Godwin J, Ebuete AW. Potential cancer and non-cancer hazard of some heavy metals in children and adults via consumption of canned chicken luncheon and Turkey luncheon. *Discovery* 2023; 59: e56d1237

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**Peer-Review History**
Received: 14 April 2023
Reviewed & Revised: 18/April/2023 to 28/April/2023
Accepted: 02 May 2023
Published: May 2023

**Peer-Review Model**
External peer-review was done through double-blind method.

Discovery
pISSN 2278–5469; eISSN 2278–5450



# Potential cancer and non-cancer hazard of some heavy metals in children and adults via consumption of canned chicken luncheon and Turkey luncheon

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## ABSTRACT

Canned meat products contain essential nutrients and trace mineral elements required for human adequate diet. However, most materials used for coating canned meat and other canned food products are often metals and their alloys and so, when the coated steel is damaged migration of the metals or other contaminants may occur. This study evaluated the potential cancer and non-cancer hazards of Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn and Ni in children and adults via canned Zwan Chicken and Turkey Luncheon meat products. The concentrations of the metals were determined by solar thermo elemental atomic absorption spectrophotometer. The average concentrations of the metals range from 0.008 – 24.924 mg/kg in Chicken Luncheon and 0.002 – 15.519 mg/kg in Turkey Luncheon. Mn, Pb, Ni and Cr levels were above permissible limits while, Zn, Fe, Cu and Cd were lower than permissible limits of regulatory bodies. The non-carcinogenic hazard revealed that, the exposed population is at safe limits (HI < 1) while the carcinogenic hazard showed that the cumulative cancer hazards (∑ IELCH) were higher than the threshold limits of $10E^{-06}$ – $10E^{-04}$. Furthermore, the results pointed out that Pb was a major contributor to the cancer and non-cancer hazards, accounting over 90% of the HI and IELCH values. In addition, the study revealed that children are more susceptible to carcinogens and non-carcinogens compared to adults. Therefore, regular monitoring and periodic evaluation of these canned meat products should be carried out by the Nigerian food safety regulatory bodies.

**Keywords:** Canned meat, toxic element, food safety, elemental analysis, cancer and non-cancer hazard

## 1. INTRODUCTION

Currently, the ecosystem (air, soil and water) is at high risk of relative toxic elements characterized as heavy metals and other environmental contaminants (Alengebawy et al., 2021; Ali et al., 2019). Their presence is exacerbated by the

uncontrolled anthropogenic activities such as agricultural activities (addition of fertilizers, pesticide etc. to soils), industrial activities (mining of metals, quarrying, development of food technologies etc.), crude oil exploration and exploitation, road construction, transportation etc. (Timothy and Tagui, 2019; Wu et al., 2016; Markmanuel and Horsfall, 2015). These toxic elements (heavy metals) find its ways into the food chain and bio-magnify within the food chain which could pose potential health hazards to the ecological community (Zhang et al., 2021; Markmanuel and Horsfall, 2016). Humans could be exposed to heavy metals via oral ingestion (food), drinking (water), dermal (skin absorption) and inhalation (air). As a matter of facts, any of the routes of exposure had posed public health concern due to their environmental persistence, bio-accumulative and bio-magnification properties (Liu et al., 2013).

Meat contains about 23% Proteins and ranked among the most significant, nutritious and flavored food items (Ahmad et al., 2018). Unfortunately, meat is a perishable food; prompt to spoilage and pathogenic bacteria (Ebuete et al., 2020), which called for canning; to prolong shelf life, other advantages include; freshness, easy transportation and distributions, budget friendly, ease usage etc. and this could be prestigious to consumers (Lewis, 2015). Based on the aforementioned advantages, the demand for canned meat (canned beef, chicken and turkey etc.) is on the increase worldwide (Sobhanardakani, 2018). In addition, canned meat contains essential nutrients and trace mineral elements needed for human adequate diet. However, the materials used for canning and packaging are often metals and their alloys (tin-plate coated steel, chromium coated steel or aluminum) coated inward with resin to prevent the food content from contaminants or toxicants (heavy metals; Pb, Hg, Fe, Cr, Sn etc) (Markmanuel et al., 2022). Nevertheless, these protective actions against contamination or toxicity have further enhanced the migration of contaminants into the edible content of the food especially when coating is damaged. As such, canned food products (fish, meat beverages etc.) are labelled with questionable mark in respect to safety (Kassouf et al., 2013, Fiamegos et al., 2016).

Over the years, food safety has become a menace due to environmental contamination (soil, water and air) from source to production and down to the final consumers. Recent studies (Markmanuel et al., 2022, 2021, 2020; Markmanuel and Markbere 2020; Liu, et al., 2022; Sobhanardakani, 2018, 2017; Sultana et al., 2017; Vasile et al., 2014; Hamasalim and Muhammed, 2013), have shown that unsafe food are the major sources of most acute and chronic diseases such as vomiting, diarrhea, stomachache, cancer, heart related diseases, kidney failure, diabetes etc. and in severe case death may occur. Therefore, it is eminent to investigate the potential cancer and non-cancer adverse effect of heavy metals (Pb, Cd, Cr, Cu, Mn, Fe, Sn, Ni and Hg) in children and adults via consumption of canned Chicken Luncheon and Turkey Luncheon from Bayelsa State.

## 2. 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 $4^{O}55^{I}29^{II}$N and $6^{O}15^{I}51^{II}$E, with an area of 706 $km^2$.

**Sample Collection and Preparation**

Total of 15 Zwan Chicken Luncheon and Zwan Turkey Luncheon were bought from Swali, Yenagoa main market and transported to the Central Research Laboratory in the Department of Chemical Sciences, Faculty of Science, Niger Delta University, Bayelsa State. Thereafter, the edible tissue of each canned meat content was carefully removed, rinsed thoroughly with distilled water and oven-dried between 80-$100^0$ C to a constant weight. The dried samples were ground and sieved to uniform particle size and labelled accurately.

**Sample Digestion and Elemental Analysis**

The dried-biomass was pre-digested with 10 mL mixture of conc. $HNO_3/H_2SO_4$ in 3:1 V/V at room temperature for 12 hours. Thereafter, 5 mL of $HNO_3/H_2SO_4$ was also added and heated in a fume cupboard between 60-75 minutes at temperature range of 85-$100^0$ C and approximate 5 mL clear solution was obtained and 25 mL distilled water was added to each content in 100 mL flask. The cooled and filtered digests were top up in 100 mL flask with distilled water to make up the mark (Markmanuel et al., 2022; Mohammed et al., 2017).

Elemental analysis of Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn and Ni were determined on each digest using Solar -thermo-elemental Atomic Absorption Spectrophotometer (FAAS), S4-71096 model. All analysis was done in triplicates.


**Figure 1** Map of Bayelsa State showing Yenagoa

**Hazard Evaluation**

The potential hazard of human exposure to the heavy metals (Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn and Ni) via consumption of the canned Chicken Luncheon and Turkey Luncheon were estimated using the United State Environmental Protection Agency Models (USEPA, 2017, 2016, 2012, 2011, 2005, 2001) to evaluate the cancer and non-cancer hazards.

**Non-cancer Hazard**

The non-cancer hazard was expressed using the following equations:

a. $ADI_m = \frac{M_{cm} \times IR_m}{BW_{(c:a)}}$ ……1

$ADI_m$ is the average daily intake (mg/kg-bw/day) of the metal in the meat (Chicken and Turkey); $M_{cm}$ is the metal concentrations in the meat samples; $IR_m$ is the daily ingestion rate of the meat by Bayelsa people, adult (0.30 mg/kg/person/day) and children (0.15 mg/kg/person/day). $Bw_{c:a}$ is the average body weight for adults (60 kg) and children (25 kg) respectively (Markmanuel et al., 2022).

b. $CDI_m = \frac{ADI_m \times EF \times ED}{AT} \times 10^{-3}$ ……..2

Where, $CDI_m$ is the chronic daily intake (mg/kg-bw/day) of the metals. EF is the exposure frequency (365days/year); ED is the exposure duration (70 years for adults and 15 years for children); AT is the average exposure lifetime for non-carcinogens (EF × ED) for children (365 days/year × 15 years) and adults (365 days/years × 70 years).

c. $THQ_m = \frac{CDI_m}{RfD_m}$ …….. 3

Where, THQ is the Target Hazard Quotient of the individual heavy metal in the canned meat (Chicken and Turkey meat) and it defines the non-cancer hazard of the metals in the canned meat; RfD (mg/kg-bw-day) is the oral reference dose of the metals. The RfD (mg/kg-bw/day) expresses the daily acceptable dose of exposure to contaminants, including the sensitive and vulnerable

groups such as children, elderly, pregnant women etc. The RfD of the metals under investigation were Pb ($3.5E^{-04}$), Cd ($1.0E^{-03}$), Cr ($1.5E^{-01}$), Cu ($4.0E^{-02}$), Mn ($1.4E^{-01}$), Fe ($3.0E^{-01}$), Sn ($2.0E^{-01}$), Zn ($3.0E^{-01}$), Ni ($2.0E^{-02}$) (Markmanuel et al., 2019; USEPA, 2016).

d. HI = $\sum THQ_{ml}$

Where, HI is the total sum of the Hazard Indices of all the metals; and I is the individual heavy metal investigated.

:. HI = $THQ_{pb} + THQ_{cd} + THO_{cr} + THQ_{cu}$ …… n ……. 4

Note; the summation of all the individual heavy metals in the matrix (canned meat were combine to form the Hazard Index (HI). The upper toxicity factor acceptable for HI is 1 and where HI is >1, it implies that the exposed consumers are at risk and when HI <1, it implies that the exposed consumer is safe.

**Cancer Hazard**

The probability of cancer hazard posed by the heavy metals via consumption of the canned chicken and turkey were evaluated as the Individual Excess Lifetime Cancer Hazard, IELCH (Liu et al., 2013). IELCH is estimated as the possibility of individual contracting cancer over time due to exposure to heavy metals in the studied canned Chicken and Turkey and is expressed as follows;

IELCH = $CDI_m / CSfo_m$

Where IELCH is the Individual Excess Lifetime Cancer Hazard; $CDI_m$ is the chronic daily intake of the carcinogenic heavy metals (Pb, Cr, Ni, Cd and Hg) mg/kg-bw/day and it indicates the life time average dose of the heavy metal in the canned Chicken and Turkey, $CSfo_m$ is the cancer slope factor oral (mg/kg-Bw/day). The $CSfo_m$ for the metals were Pb ($8.5E^{-04}$), Cd ($3.8E^{-02}$) Cr ($5.0E^{-01}$), Ni ($1.7E^{-01}$) and the cumulative cancer hazard as a result of exposure to multiple carcinogens (heavy metals in this study) was calculated as follows; $\sum IELCH = IELCH_{Pb} + ielch_{Cd} + IELCH_{Cr} + IELCH_{Ni}$

The acceptable threshold values for toxicity limits for carcinogenic substances are within the range of $10E^{-06}$ – $10E^{-04}$ (one in a million to one in a thousand in a given population).

**Statistical Data Analysis**

The triplicate experimental data obtained from the canned meat products (Chicken and Turkey) in this study were statistically analyzed for mean, standard deviation, standard errors and range using SPSS Microsoft Excel 2019. The mean concentration of the heavy metals in the canned food products were also tested using one-way analysis of variance (ANOVA) to unlock the variation between the sample mean at 95% confidence level and to ascertain accurately which sample vary significantly when $P < 0.05$ and insignificantly when $p > 0.05$.

## 3. RESULTS AND DISCUSSION

**Heavy Metals Levels in Canned Chicken Luncheon and Turkey Luncheon**

Different environmental media had been implicated as the key footpath for heavy metals contamination in food produce and products. Examples are ingestion of polluted fish, meat, water and agricultural produce of plant origins, inhalation of polluted air and dust, absorption of petroleum products by aquatic and terrestrial organism down to consumption of processed and canned food products.

Recent studies (Markmanuel et al., 2022; Ghoul et al., 2020; Grazyna et al., 2020; Sobhanardakani, 2018, 2017; Vasile et al., 2014; Hamasalim and Mohammed, 2013) had revealed that processing and canning of food products are the major route to heavy metals bioaccumulation, which had gained prominence public health concern in regards to food hygiene and safety for public consumption. Thus, the current study also showed that heavy metals (Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn and Ni) are present in canned Chicken Luncheon and Turkey Luncheon meat products sold in Bayelsa State (Table 1).

The mean levels of the heavy metals (mg/kg) in the canned meat products (Chicken and Turkey Luncheon) in comparison with standard guidelines values of EC, (2013), FAO/WHO and IAEA, (2016) are presented (Table 1). The experimental data shows that the concentrations of the heavy metals ranged from 0.008 mg/kg – 24.924 mg/kg in chicken luncheon. Zn recorded the highest mean level of 24.924 mg/kg and Cd recorded the lowest mean level of 0.008 mg/kg. Thus, the concentrations of the studied heavy metals are in the hierarchical order of Zn > Mn > Fe > Cr > Ni > Sn > Cu > Pb > Cd, while the concentrations (mg/kg) of the heavy metals in Turkey Luncheon range from 0.002 mg/kg – 15.519 mg/kg. Also, Zn ranked the highest with mean level of 15.519 mg/kg and Cd ranked the lowest (0.002 mg/kg). As indicated in Table 1, the mean levels of the studied metals in Turkey Luncheon follow the hierarchical order of Zn > Mn > Fe > Sn > Cu > Ni > Cr > Pb > Cd.

**Table 1** Mean Level of Heavy Metals (mg/kg) in Canned Chicken Luncheon and Turkey Luncheon Meat Products in Comparison with Standard Guideline Values

| Heavy metals | Statistics | Processed Meat Samples | | Standard Guideline Values | | |
|---|---|---|---|---|---|---|
| | | Zwan Chicken Luncheon | Zwan Turkey Luncheon | EC (SRLs) | FAO/WHO | IAEA |
| Pb | Range | 3.038 - 2.029 | 1.301 – 1.302 | 0.010 | 0.025 | 0.120 |
| | Mean ± SD | 2.038 ± 0.001 | 1.302 ± 0.001 | | | |
| | SE | 0.000 | 0.000 | | | |
| Cd | Range | 0.007 – 0.009 | 0.002 – 0.003 | 0.005 | 0.003 | 0.180 |
| | Mean ± SD | 0.008 ± 0.001 | 0.002 ± 0.001 | | | |
| | SE | 0.001 | 0.000 | | | |
| Cr | Range | 2.814 – 2.817 | 1.471 – 1.473 | 0.250 | 0.300 | 0.730 |
| | Mean ± SD | 2.815 ± 0.002 | 1.471 ± 0.002 | | | |
| | SE | 0.001 | 0.001 | | | |
| Cu | Range | 2.050 – 2.052 | 2.939 – 2.941 | 4.000 | 20.000 | 3.280 |
| | Mean ± SD | 2.051 ± 0.001 | 2.942 ± 0.001 | | | |
| | SE | 0.001 | 0.001 | | | |
| Mn | Range | 13.055 – 13.056 | 10.430 – 10.433 | 1.800 | 0.040 | 3.280 |
| | Mean ± SD | 13.056 ± 0.001 | 10.432 ± 0.002 | | | |
| | SE | 0.000 | 0.001 | | | |
| Fe | Range | 5.030 – 5.031 | 7.498 – 7.501 | 40.000 | 0.000 | 146.000 |
| | Mean ± SD | 5.030 ± 0.001 | 7.499 ± 0.002 | | | |
| | SE | 0.000 | 0.001 | | | |
| Sn | Range | 2.546 – 2.550 | 5.833 – 5.834 | 200.000 | 200.000 | - |
| | Mean ± SD | 2.548 ± 0.002 | 5.832 ± 0.002 | | | |
| | SE | 0.001 | 0.001 | | | |
| Zn | Range | 24.923 – 24.926 | 15.519 – 15.520 | 50.000 | 50.000 | 67.100 |
| | Mean ± SD | 24.924 ± 0.002 | 15.519 ± 0.001 | | | |
| | SE | 0.001 | 0.001 | | | |
| Ni | Range | 5.260 – 2.561 | 1.914 – 1.916 | 0.140 | 0.050 | 0.600 |
| | Mean ± SD | 2.560 ± 0.001 | 1.915 ± 0.001 | | | |
| | SE | 0.001 | 0.001 | | | |

SD – Standard Deviation
SE – Standard Error
EC (SRLs) – EC Specific Release Limits
FAO – Food Agricultural Organization
WHO – World Health Organization
IAEA – International Atomic Energy Agency

The variability of the experimental data was also tested with ANOVA and the results showed that the concentrations of the studied metals in each canned meat products (Chicken and Turkey Luncheon) varied significantly $P > 0.05$. This could be attributed to contamination from source (source of the meat), handling, processing and canning methods and materials (Morshdy et al., 2023; Robertson, 2016; Buculei et al., 2014). The mean levels of the studied heavy metals were compared to standard guidelines limits of EC, (2013), FAO/WHO, (2011) and IAEA, (2016) (Table 1). The mean levels of the studied metals Mn, Pb, Ni and Cr were above the standard permissible limits of EC, (2013), FAO/WHO, (2011) and IAEA, (2016) while, Zn, Fe, Cu and Cd were lower than permissible limits in both Chicken Luncheon and Turkey Luncheon meat products. As indicated in Table 1, it is very crucial to note that, the mean concentration of Mn in both meat products were extremely high compared to the standard guideline values of regulatory bodies. Although Mn is a micro-nutrient that plays vital role in the metabolism of carbohydrate, cholesterol and protein in the human body, however, study has showed that, high level of acute and low level of chronic toxicity could cause neurotoxicity and anemic patient are prompt to Mn toxicity due to high assimilation during iron deficiency (Martin, 2006). Therefore, the high level of Mn in the canned Chickens and Turkey Luncheon from this study is a source of concern to consumers.

The concentration of the heavy metal in this study is similar to the findings of Al-Thagafi et al., (2014) which ranges from 0.20 – 24.14 mg/kg in canned food. However, Hamasalim and Mohammed, (2013), Al-zuhair et al., (2015) and Al-rajhi, (2014) reported low values in canned chicken which ranges from 0.00 – 4.22, mg/kg; 0.132 – 4.550 mg/kg and 0.0010 – 0.019 mg/kg. Also, Morshdy et al., (2023) reported low range values of 0.091 – 5.050 mg/kg in canned Chicken Luncheon from Egypt.

**Potential Cancer and Non-cancer Hazard**

The potential probability of cancer and non-cancer hazard of the studied heavy metals (Pb, Cd, Cr, Cu, Mn, Fe, Sn, Zn and Ni) were evaluated in order to assessed the detrimental adverse health risks that may be experienced by children and adults consuming canned Zwan Chicken Luncheon and Zwan Turkey Luncheon in Bayelsa State. The model employed for cancer and non-cancer hazard of the studied heavy metal were; average daily intake (ADIm), chronic daily intake (CDIm), target hazard quotient (THQm) for non-carcinogens; and incremental excess life time cancer hazard (IELCH) and the sum total effects $\sum IELCH$ of the heavy metals (Pb, Cd, Cr and Ni) in the canned Chicken and Turkey Luncheon. The mean concentrations of the heavy metals were imputed in the hazard models and the results are presented (Table 2, 3, 4). The acceptable toxicity limits for cancer and non- cancer hazard set by the USEPA (USEPA, 2017, 2016, 2012, 2011, 2005, 2001) were $10E^{-06}$ – $10E^{-04}$ (carcinogenic hazard) and $\sum THQ$ = HI $< 1$ (non-carcinogenic hazards). These are the upper threshold safe limits for a 95% centile of the population who are unlikely to experienced adverse health hazard over a long period of time (70 years, the assumed lifetime). However, when the limits value is greater than $10E^{-06}$ – $10E^{-04}$ (one in a million, one in a thousand) for carcinogenic hazard and HI $> 1$ (non-carcinogenic hazard), it implies that the exposed population (children and adults) are unsafe.

**Table 2** Average Daily Intake $ADI_m$ (mg/kg-bw/day/person) and Chronic Daily Intake $CDI_m$ (mg/kg-bw/day/person) of the heavy metals in the canned Chicken and Turkey Luncheon

| Heavy metals | Hazard Model | Children | | Adults | | Acceptable Daily Guideline of FAO/WHO |
|---|---|---|---|---|---|---|
| | | Zwan Chicken Luncheon | Zwan Turkey Luncheon | Zwan Chicken Luncheon | Zwan Turkey Luncheon | |
| Pb | $ADI_m$ | $1.22E^{-02}$ | $7.81E^{-02}$ | $1.02E^{-02}$ | $6.51E^{-03}$ | $3.00E^{-04}$ |
| | $CDI_m$ | $1.22E^{-05}$ | $7.81E^{-06}$ | $1.02E^{-05}$ | $6.51E^{-06}$ | |
| Cd | $ADI_m$ | $4.80E^{-05}$ | $1.20E^{-05}$ | $4.00E^{-05}$ | $1.00E^{-05}$ | $3.00E^{-04}$ |
| | $CDI_m$ | $4.80E^{-08}$ | $1.20E^{-08}$ | $4.00E^{-08}$ | $1.00E^{-08}$ | |
| Cr | $ADI_m$ | $1.69E^{-02}$ | $8.83E^{-03}$ | $1.41E^{-02}$ | $7.36E^{-03}$ | $3.00E^{-01}$ |
| | $CDI_m$ | $1.69E^{-05}$ | $8.83E^{-06}$ | $1.41E^{-05}$ | $7.36E^{-06}$ | |
| Cu | $ADI_m$ | $1.23E^{-02}$ | $1.76E^{-02}$ | $1.03E^{-02}$ | $1.47E^{-02}$ | $8.00E^{-02}$ |
| | $CDI_m$ | $1.23E^{-05}$ | $1.76E^{-05}$ | $1.03E^{-05}$ | $1.47E^{-05}$ | |
| Mn | $ADI_m$ | $7.83E^{-02}$ | $6.26E^{-02}$ | $6.53E^{-02}$ | $5.22E^{-02}$ | $9.00E^{-02}$ |
| | $CDI_m$ | $7.83E^{-05}$ | $6.26E^{-05}$ | $6.53E^{-05}$ | $5.22E^{-05}$ | |
| Fe | $ADI_m$ | $3.02E^{-02}$ | $4.49E^{-02}$ | $2.52E^{-02}$ | $3.75E^{-02}$ | $3.00E^{-01}$ |
| | $CDI_m$ | $3.02E^{-05}$ | $4.49E^{-05}$ | $2.52E^{-05}$ | $3.75E^{-05}$ | |
| Sn | $ADI_m$ | $1.53E^{-02}$ | $3.49E^{-02}$ | $1.27E^{-02}$ | $2.92E^{-02}$ | $2.20E^{-01}$ |
| | $CDI_m$ | $1.53E^{-05}$ | $3.49E^{-05}$ | $1.27E^{-05}$ | $2.92E^{-05}$ | |
| Zn | $ADI_m$ | $1.49E^{-01}$ | $9.31E^{-02}$ | $1.25E^{-02}$ | $7.76E^{-02}$ | $4.00E^{-01}$ |
| | $CDI_m$ | $1.49E^{-05}$ | $9.31E^{-05}$ | $1.25E^{-04}$ | $7.76E^{-05}$ | |
| Ni | $ADI_m$ | $1.54E^{-02}$ | $1.15E^{-02}$ | $1.28E^{-02}$ | $9.58E^{-03}$ | $2.00E^{-02}$ |
| | $CDI_m$ | $1.54E^{-05}$ | $1.15E^{-05}$ | $1.28E^{-05}$ | $9.58E^{-06}$ | |

**Non-carcinogenic Hazard**

The average daily intake ($ADI_m$) of the metal is the amount of nutrient content ingested from the canned Chicken and Turkey Luncheon which is considered adequate for a daily healthy living of an individual. While the chronic daily intake ($CDI_m$) of the metal is the amount of nutrient content of the canned meat products (Chicken and Turkey Luncheon) exposed to by an individual over a long period (70 years the assumed lifetime), which is unlikely to produce any adverse health effect in the future. Table 2 shows the $ADI_m$, $CDI_m$, of the heavy metals.

**Table 3** Non-carcinogenic Health Hazard of Children and Adults via Consumption of Canned Chicken Luncheon and Turkey Luncheon

| Heavy metals | Hazard Model | Children | | Adults | |
|---|---|---|---|---|---|
| | | Zwan Chicken Luncheon | Zwan Turkey Luncheon | Zwan Chicken Luncheon | Zwan Turkey Luncheon |
| Pb | $THQ_m$ | $3.06E^{-02}$ | $1.95E^{-02}$ | $2.55E^{-02}$ | $1.63E^{-02}$ |
| | % HI | 92.6545 | 90.0548 | 92.6545 | 90.0548 |
| Cd | $THQ_m$ | $4.80E^{-05}$ | $1.20E^{-05}$ | $4.00E^{-05}$ | $1.00E^{-05}$ |
| | % HI | 0.1455 | 0.0553 | 0.1455 | 0.0553 |
| Cr | $THQ_m$ | $1.13E^{-04}$ | $5.89E^{-05}$ | $9.38E^{-05}$ | $4.90E^{-05}$ |
| | % HI | 0.3413 | 0.2713 | 0.3413 | 0.2713 |
| Cu | $THQ_m$ | $3.08E^{-04}$ | $4.41E^{-04}$ | $2.56E^{-05}$ | $3.68E^{-05}$ |
| | % HI | 0.9325 | 2.0335 | 0.9325 | 2.0335 |
| Mn | $THQ_m$ | $5.59E^{-04}$ | $4.47E^{-04}$ | $4.66E^{-04}$ | $3.73E^{-05}$ |
| | % HI | 1.6959 | 2.0616 | 1.6959 | 2.0616 |
| Fe | $THQ_m$ | $1.01E^{-04}$ | $1.49E^{-0E}$ | $8.38E^{-05}$ | $1.25E^{-04}$ |
| | % HI | 0.3049 | 0.6916 | 0.3049 | 0.6916 |
| Sn | $THQ_m$ | $7.64E^{-05}$ | $1.75E^{-04}$ | $6.37E^{-05}$ | $1.46E^{-04}$ |
| | % HI | 0.2317 | 0.8068 | 0.2317 | 0.8068 |
| Zn | $THQ_m$ | $4.98E^{-04}$ | $3.10E^{-04}$ | $4.15E^{-04}$ | $2.59E^{-04}$ |
| | % HI | 1.5108 | 1.4312 | 1.5108 | 1.4312 |
| Ni | $THQ_m$ | $7.68E^{-04}$ | $5.75E^{-04}$ | $6.40E^{-04}$ | $4.79E^{-04}$ |
| | % HI | 2.3277 | 2.6491 | 2.3277 | 2.6491 |
| | HI | 0.0330 | 0.0217 | 0.0275 | 0.0180 |

% HI is the percentage contribution of each metal to HI

**Table 4** Carcinogenic Health Hazard of Children and Adults via Consumption of Canned Chicken Luncheon and Turkey Luncheon

| Heavy metals | Hazard Model | Children | | Adults | |
|---|---|---|---|---|---|
| | | Zwan Chicken Luncheon | Zwan Turkey Luncheon | Zwan Chicken Luncheon | Zwan Turkey Luncheon |
| Pb | IELCH | $1.46E^{-02}$ | $9.30E^{-03}$ | $1.21E^{-02}$ | $7.75E^{-03}$ |
| | % IELCH | 99.1459 | 99.0884 | 99.1460 | 99.0884 |
| Cd | IELCH | $1.26E^{-06}$ | $3.16E^{-07}$ | $1.05E^{-06}$ | $2.63E^{-07}$ |
| | % IELCH | 0.0086 | 0.0034 | 0.0086 | 0.0034 |
| Cr | IELCH | $3.38E^{-05}$ | $1.77E^{-05}$ | $2.82E^{-05}$ | $1.47E^{-05}$ |
| | % IELCH | 0.2301 | 0.1881 | 0.2301 | 0.1881 |
| Ni | IELCH | $9.04E^{-05}$ | $6.76E^{-05}$ | $7.53E^{-05}$ | $5.63E^{-05}$ |
| | % IELCH | 0.6154 | 0.7201 | 0.6154 | 0.7201 |
| | $\sum IELCH$ | $1.47E^{-02}$ | $9.39E^{-03}$ | $1.22E^{-02}$ | $7.82E^{-03}$ |

The $ADI_m$ of the metals ranges from $4.80E^{-05}$ – $1.49E^{-01}$ mg/kg-bw/day/person for Zwan Chicken Luncheon and $1.20E^{-05}$ – $9.3E^{-02}$ mg/kg-bw/day/person for Zwan Turkey Luncheon in children. While, $ADI_m$ of the metals in adult's ranges from $4.00E^{-05}$ – $7.76E^{-02}$ mg/kg-bw/day/person for Zwan Chicken Luncheon and $1.00E^{-05}$ – $7.76E^{-02}$ mg/kg-bw/day/person for Zwan Turkey Luncheon. The highest $ADI_m$ value was found in Zn and the lowest $ADI_m$ value was found in Cd in both children and adults. The $ADI_m$ of the metals in the canned Chicken and Turkey Luncheon was also compared to the standard guideline's daily limits (mg/kg-bw/day/person) of FAO/WHO, (2011) (Table 2), which indicates safe limits. Also, the $CDI_m$ and $THQ_m$ of the metals in the canned meat products (Chicken and Turkey Luncheon) for both children and adult were below the oral reference dose RfD of the heavy metals.

The $CDI_m$ and $THQ_m$ define the chronic/repeated exposure of an individual/population to contaminants or toxicants over a long period of time. Their values are comparative measure to the RfD of the contaminants/toxicants (USEPA, 2016). The hazard index HI ($\sum$THQ of all the heavy metals) defines sum total or the combine interactive hazard of toxicants or contaminants in given matric to produce adverse deleterious effect over a long period (Markmanuel et al., 2020). Table 3 shows the HI values of all the metals in the canned meat products which was; 0.0330 (Chicken Luncheon) and 0.0217 (Turkey Luncheon) for children and 0.0275 (Chicken Luncheon) and 0.0180 (Turkey Luncheon) for adults. The HI values for both children and adults were less than one (HI > 1). This implies that children and adults consuming these canned meat products are unlikely to experience non-carcinogenic hazard at the moment.

However, it worthy to note that, Pb contributed between 90-92% to the total HI values for both children and adults in each canned meat product. This is alarming, coupled from the fact that Pb has no biological role in the human system rather, its accumulation has been reported to evoke deleterious adverse health effects such as memory loss, infertility, damage of the central nervous system, kidney, liver, coma and in severe cases death (Malekirad et al., 2010; WHO, 2016; UNEP/OCHA, 2010). Therefore, these canned meat products (Zwan Chicken and Turkey Luncheon) should be consumed moderately.

**Carcinogenic Hazard Evaluation**

Carcinogenic hazard was evaluated to assess the potential probability of an individual (children and adults) contracting cancer via the consumption – Zwan Chicken and Turkey Luncheon over a long period (70 years), the assumed lifetime. The hazard model for carcinogens was evaluated based on the incremental excess lifetime cancer hazard (IELCH) of the metals (Pb, Cd, Cr and Ni) in the canned meat products and the results were presented (Table 4).

The data showed that the IELCH values of Cd and Cr were within the acceptable threshold limits of $10E^{-06}$ – $10E^{-04}$, while Pb and Cd were above the acceptable threshold values by USEPA, (2017). The results also revealed that Pb was a major contributor to the total % IELCH values, accounting over 90% of the IELCH values. More importantly, the combined interactive effects of the carcinogenic metals ($\sum IELCH$) values for Zwan Chicken and Turkey Luncheon meat products were all above the acceptable threshold values of $10E^{-06}$ – $10E^{-04}$ respectively. This indicates that, the exposed population (children and adults) are likely to contract cancer via the consumption of these canned meat products over a long (70 years for adults and 15 years for children).

Generally, the results in Table 3 and 4 shows that children are more vulnerable to carcinogens and non-carcinogens in the current study compared to adults. The report of this current study is in agreement with the findings of Markmanuel et al., (2020), Birnbaum and Fenton, (2005), Siiker et al., (2004), Ginsberg, (2003) and Scheuphim et al., (2002). Their findings revealed that the vulnerability of children to carcinogens and their effects are based on the differences in ability of children to metabolize higher doses of chemicals due to developmental stages in children which are accompanied by continuous cell division and could promote cell mutation. Also, they penned that, children's immune systems are still under development, hence are prompt to attack by carcinogens and the human hormonal systems operate at different levels during life stages and as such developmental abnormalities of cells and tissues could cause susceptibility to carcinogens etc.

The hierarchical order of carcinogenicity of the heavy metals in the Zwan Chicken and Turkey Luncheon for both children and adults were in the decreasing order of Pb > Ni > Cr > Cd, while the non-carcinogenic hazard of the heavy metals was in the hierarchical order of Pb > Ni > Mn > Zn > Cu > Cr > Fe > Sn > Cd for Zwan Chicken Luncheon and Pb > Ni > Mn > Cu > Zn > Sn > Fe > Cr > Cd for Zwan Turkey Luncheon. Among the heavy metals investigated, Pb posed the greatest carcinogenic and non-carcinogenic hazard for both children and adults.

## 4. CONCLUSION

The current study evaluated the potential cancer and non-cancer hazard of some heavy metals in Zwan Chicken and Turkey Luncheon meat products exposed to children and adult via oral ingestion. The results revealed that, the mean concentrations of Mn, Pb, Ni and Cr were above standard permissible limits set by regulatory bodies (EC, 2013; FAO/WHO, 2011; IAEA, 2016), while the mean values of Zn, Fe, Cu and Cd were below their standard permissible limits. The non-carcinogenic health hazard showed that HI values of the metals in the canned meat products were less than one (HI < 1) which indicates that the exposed population (children and adults) are safe at the moment. The carcinogenic health hazard revealed that Cd and Cr were within the safe limits of $10E^{-06}$ – $10E^{-04}$, while Pd and Ni were above the safe limits. However, the $\sum IELCH$ values for each canned meat product were higher than safe limits for carcinogens. Generally, the results showed that Pb was a major risk contributor to cancer and non-cancer hazard in both children and adults, accounting over 90% of the HI and IELCH values. Thus, in view of the non-biochemical function of Pb

in the human system, these canned meat products should be consumed moderately to avoid adverse deleterious health hazards in future.

**Acknowledgement**

The authors wish to acknowledge the staffs of Austino Research and Analysis Laboratory Nig. Ltd, for the use of their equipment (FAAS) for the elemental determination.

**Informed consent**

Not applicable.

**Ethical approval**

The ethical guidelines are followed in the study for sample collection & experimentation.

**Conflicts of interests**

The authors declare that there are no conflicts of interests.

**Funding**

The study has not received any external funding.

**Data and materials availability**

All data associated with this study are present in the paper.

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