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Research Article

Health Risk of Ingested Heavy Metals in Fluidized Canned Milks: Are We Drinking Heavy Metals?

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This study examined the heavy metal level of canned milk consumed in Calabar, Cross River State, as well as the health risks linked to it. Peak Milk, Three Crown, Coast, Nunu, Cowbell, and Olympic milk types were chosen for research. During the digestion of samples, 0.5 mol of nitric acid was added to the sample and heated. The heated liquid was slowly heated with 2.5 mL of 70% $HClO_4$ until a dense white vapor was formed. After cooling the mixture, 10 mL of deionized water was added and the solution was boiled to expel the fumes. The heavy metals were screened using an atomic absorption spectrophotometer. All milk samples contained eight heavy metals: iron (Fe), copper (Cu), zinc (Zn), arsenic (As), lead (Pb), cadmium (Cd), manganese (Mn), and nickel (Ni). Peak Milk and Nunu both had Cd. Nickel was found in various quantities in Coast, Cowbell, Nunu, and Olympic. Coast, Nunu, and Cowbell samples all contained Mn. Nunu and Cowbell both tested positive for lead. Peak Milk did not contain copper (Cu). Standard models for daily consumption of different heavy metals, such as Pb in Nunu ($3.7E-03$) and Cowbell ($-1.8E-03$), were used to construct the health risk evaluations. Peak Milk, Three Crown, and Nunu had daily Cd intakes of ($4.5E-06$), ($2.2E-05$), and ($4.5E-06$), respectively. Coast ($3.2E-02$), Nunu ($5.1E-02$), Cowbell ($1.9E-02$), and Olympic ($3.8E-02$) have different daily Ni intakes. Peak Milk ($1.1E-01$), Three Crown ($2.2E-01$), Coast ($1.6E-01$), Nunu ($7.1E-01$), Cowbell ($1.4E-01$), and Olympic ($1.1E-01$) have different daily intakes of Ar. Peak ($6.0E-04$), Three Crown ($8.0E-04$), Coast ($6.0E-04$), Nunu ($7.0E-04$), Cowbell ($8.0E-04$), and Olympic ($6.0E-04$) had different daily Zn intakes. Daily Fe intakes of Peak Milk was ($1.6E-01$), Three Crown was ($1.6E-01$), Coast was ($1.4E-01$), Nunu was ($1.4E-01$), Cowbell was ($2.4E-01$), and Olympic was ($1.8E-01$). Cu intakes per day for Three Crown, Coast, Nunu, Cowbell, and Olympic were ($6.0E-03$), ($4.0E-03$), ($2.0E-03$), ($2.0E-03$), and ($4.0E-03$), respectively. Coast, Nunu, and Cowbell had daily Mn intakes of ($2.0E-04$), respectively. The total hazard index (THI) and the target hazard quotient (THQ) were also calculated. Peak Milk ($1.7E-01$), Three Crown ($3.4E-01$), Coast ($2.8E-01$), Nunu ($1.9E-01$), Cowbell ($2.4E-01$), and Olympic ($2.3E-01$) induced cancer risks, accordingly. According to the findings, the risk of drinking milk is relatively considerable when compared to the acceptable limit.

1. Introduction

Heavy metals are common minerals found in nature, and because they are non-biodegradable, they can easily accumulate in food chains [1]. The metal content of milk and milk products can be divided into two groups: essential elements that are necessary but only in small amounts, such as copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn), and nonessential elements that are required but only in small amounts (Zn). The second category includes nonessential elements such as arsenic (As), lead (Pb), and cadmium (Cd), which have no biological function [2]. These dangerous metals are classified as air pollutants that are produced and disseminated by them mostly as a result of diverse industrial operations [3], from which they reach soil, plants, foods, and water, contaminating them [4]. As a result, they are easily ingested by dairy animals while grazing on the pasture, through contaminated concentrate diets, or even from water. These metals are then transported to milk in the animal [5]. Despite the fact that breathing is a required route of Pb and Cd transmission, particularly in highly polluted areas, food remains the primary route of exposure, accounting for about 90% of total consumption [3]. The existence of Pb and Cd residues in milk and other milk products is of particular importance, as their presence, even at small levels, causes poisoning and other serious health problems [6]. They are also regarded as possible carcinogens [7]. Cu, on the other hand, is a necessary micronutrient for our body's regular operation because it is required for iron absorption and as a cofactor of specific enzymes that are required for other vital functions [8]. However, consuming copper in amounts greater than the acceptable levels suggested by international organizations can be harmful to human health, and this is primarily owing to the availability of Cu in high concentrations in animal feed [9]. To maintain consumer safety, it is required to check milk and other milk products for the presence of residual metal concentrations and assess their possible health concerns. It is critical to determine the dietary intake of these metals and compare it to the permitted limits (PL) set by regulatory agencies for this reason [10]. Furthermore, the target hazard quotient (THQ) is one of the methods for assessing the possible health risks associated with the ingestion of various contaminants in humans [11]. As metal may enter the milk through the aging container, during shipping, and during storage. Even though heavy metals can be removed from food using technology, this may be practicable in fresh fruits and vegetables, by adopting methods such as chemical treatment, flocculation, coagulation, membrane separation, filtration, and adsorption [12–15]. Adsorption is a process that has a basic design, is minimal in cost, and does not produce sludge [16]. Many research studies [17] have reported that resin is a novel chelating ion exchange employed for the removal of heavy metals using the adsorption approach due to their great selectivity in binding metal ions. The study's main goals were to quantify the levels of Pb, Cd, and Cu contamination in various types of canned milk, as well as to assess their potential health dangers for people using target health quotients (THQs). As a result, to protect consumer health, it is required to measure the residual concentration of metals in milk and assess the health hazards associated with them.

2. Materials and Methods

2.1. Collection of Milk Samples. Six different types of milk samples were purchased in the Calabar Metropolis Spar retail mall. Peak Milk, Three Crown, Nunu, Coast, Cowbell, and Olympic were the milk samples used.

2.2. Chemicals and Sample Preparation. All chemicals and reagents used in this experiment were of analytical and trace metal grades. Fisher Malaysia products had trace metal grades of 65 percent HNO_3, 37 percent HCl, and 70 percent $HClO_4$. Perkin Elmer, USA, products were stock standard solutions with a concentration of 1000 ppm for arsenic (As), cadmium (Cd), lead (Pb), nickel (Ni), zinc (Zn), copper (Cu), and iron (Fe). Throughout the investigation, deionized water was used. Merck products were sodium borohydride (NaBH4), sodium hydroxide (NaOH), L-ascorbic acid (C6H8O6), and potassium iodide (KI) (Germany). Before use, all glassware was soaked in 5 percent (v/v) HNO_3 overnight, rinsed with deionized water, and dried in a hot air oven.

2.3. Digestion of Milk Samples. 5 mL of 65 percent HNO_3 was added to the samples, and the mixture was gently heated for 30 to 45 minutes. After cooling, the liquid was slowly heated with 2.5 mL of 70 percent $HClO_4$ until dense white vapor formed. After allowing the mixture to cool, 10 mL of deionized water was added, followed by more boiling until all fumes had been expelled [18].

2.4. Procedure for Analysis. A Perkin Elmer atomic absorption spectrophotometer was used to test the heavy metals (Analyst 800). To measure the metals in canned milk samples, three different AAS techniques were applied. Metals were measured using three distinct atomization platforms: FAAS for Cu, Zn, and Fe, GFAAS for Cd, Pb, and Ni, and HGAAS for As. The aqueous sample was inhaled into the flame atomizer of the nebulizer to determine the analyte concentration in parts per million (ppm) in FAAS. GFAAS investigated lead, cadmium, and nickel. The instrument in GFAAS had a transverse heated graphite atomizer (THGA), which provided a uniform temperature distribution across the entire length of the graphite tube atomizer to avoid potential chemical interference effects. It comes with an autosampler system for accurate background correction (Zeeman correction). The HGAAS method was used to detect arsenic, which is based on the reaction of $NaBH_4$ with an acidified sample, which results in total separation of the analyte as hydride from the matrix before measurement, reducing matrix interferences. The standards and samples were reduced from a pentavalent (V) to a trivalent (III) state of arsenate. This was accomplished by combining a reducing solution containing 5% (w/v) KI, 5% (w/v) ascorbic acid, and 10% HCl. Prior to analysis, the treated samples and standards were allowed to sit at room temperature for about 40 minutes [19].

2.4.1. Daily Intake of Heavy Metals (DIM). The DIM (daily intake of heavy metals) was calculated using the approach provided in [20, 21]. We substitute the data and determine the DIM as follows:

$$\mathrm{DIM} = \frac{C_{\mathrm{metal}} \times D_{\mathrm{foodintake}}}{B_{\mathrm{averageweight}}}, \quad (1)$$

where C_{metal}, $D_{\mathrm{foodintake}}$, and $B_{\mathrm{average\ weight}}$ are the heavy metal concentrations in milk (mg/kg-1), daily milk consumption, and average body weight of milk users (350 g/kg/day), as defined in [21]. In this study, the average body weight was 62 kg, because a dietary energy intake of a healthy, well-nourished population should allow for maintaining an adequate body mass index (BMI) at the population's level of energy expenditure.

2.5. Target Hazard Quotient of Noncarcinogenic Health Risk Indices. The ratio of daily heavy metal intake to the oral reference dosage for each of the heavy metals specified in the study was used to calculate the target hazard quotients (THQs) of heavy metals in commercial milk [21]. The THQ was calculated using the following equation:

$$\text{THQ} = \frac{\text{DIM}}{R_f D_o}, \tag{2}$$

where DIM stands for daily metal intake (g/kg/day) and $R_f D_o$ stands for oral reference dosage (g/kg/day). The $R_f D$ values used in this calculation were 0.001, 1.5, 0.3, 0.7, 0.004, 0.02, 0.040, and 0.003 mg/kg/day for Cd, Zn, Fe, Pb, Mn, Ni, Cu, and Ar, respectively [22–24].

2.6. Hazard Index (HI). In equation (3), the human health risk by more than one heavy metal or a synergistic combination of two heavy metals, as well as the hazard index, was determined by adding the hazard quotients for all heavy metals, as specified in [25]. It was assumed that the amount of heavy metal that can cause harm is proportionate to the total amount of heavy metal consumed. The lifetime cancer risks of carcinogenic metals in canned milk consumed in Calabar Metropolis were computed.

$$\begin{aligned}\text{HI} = \sum \text{THQ} &= \text{THQ}_{\text{Fe}} + \text{THQ}_{\text{Zn}} + \text{THQ}_{\text{Cu}} + \text{THQ}_{\text{Cd}} \\ &+ \text{THQ}_{\text{Mn}} + \text{THQ}_{\text{Cr}} + \text{THQ}_{\text{Co}} + \text{THQ}_{\text{Ni}}\text{H} + \text{THQ}_{\text{Pb}}.\end{aligned} \tag{3}$$

Cancer risk over time and cumulative cancer risk were applied using the model in [26] as follows:

$$\text{lifetime cancer risk} = \text{DIM} \times \text{CSF}, \tag{4}$$

where DIM stands for daily metal intake (mg/kg/day) and CSF stands for cancer slope factor. Cd, As, Pb, and Ni had oral cancer slope factors of 0.38, 1.5, 0.0085, and 1.7, respectively. Any cancer risk in the 10^{-6} to 10^{-4} range is regarded as tolerable [23, 27].

The cumulative cancer risk from exposure to numerous carcinogenic heavy metals through canned milk consumption was considered the total of the individual heavy metal incremental hazards and calculated as indicated in the following equation using a constructed model [26]:

$$\text{total cancer risks} = \sum_{k=1}^{n} \text{DIM}_K \text{CSF}_k, \tag{5}$$

where EDI stands for the estimated daily intake of carcinogenic substances (mg/kg/day) and CSF stands for substance k's slope factor (mg/kg/day).

2.7. Data Analysis and Presentation. Statistical Products and Service Solutions (SPSS) version 21 was used to evaluate the data statistically. The information was presented in the form of means and standard deviations. With a significance level of $P < 0.05$, statistical significance was calculated using one-way analysis of variance (ANOVA).

The heavy metals identified in canned milk include significant amounts of lead, cadmium, and arsenic, which are over the allowed limit as shown in Table 1. Except for Peak Milk and Nunu, there were no detectable levels of cadmium in the other kinds of canned milk. Lead was found in Nunu and Cowbell, whereas copper (Cu) was found in other canned milk samples but not in Peak Milk. Nickel was not found in Peak or Three Crown milk, but it was found in canned milk. Iron and zinc were found in every canned milk.

Table 2 shows the amounts of heavy metals consumed each day through canned milk. Nunu, for example, contributed the most to daily heavy metal consumption, despite being below the oral guideline dose. Although some canned milk had a high daily consumption of arsenic, its value was within the oral reference dosage. Nunu milk had lower levels of zinc, manganese, and nickel than their oral reference doses. Nunu milk was found to be the source of excessive daily absorption of arsenic from canned milk.

Table 3 shows the target hazard quotients (THQs) of heavy metals in canned milk. Only nickel in Nunu, Three Crown, and Olympic milk had a target hazard quotient greater than 1 ($\text{THQ} > 1$) among the kinds of canned milk and heavy metals detected. The target hazard quotients for lead in each of the milk type were lower ($\text{THQ} < 1$), but by rounding the numbers, each value is not equaled to 1, with Nunu milk being the closest to 1. Target hazard quotients exist for all canned milk with detectable amounts of Cd, Mn, Ni, Cu, As, and Zn. Their combined summation or addition shows that nickel is more predominant with a THQ of 7.05, followed by arsenic with 2.774 and lastly by iron with 1.841.

All kinds of canned milk contain cancer hazards, according to the cancer risk index of carcinogenic heavy metals in canned milk. Arsenic (As) has a cancer risk that is within the permissible range of projected lifetime carcinogen risks (10^{-6}–10^{-4}). It has been determined that 2-3 people of every 100,000 who consume canned milk have an elevated lifetime cancer risk due to the toxic effects of arsenic (As). Except for Nunu and Cowbell, lead (Pb) is lower in Peak Milk, Three Crown, and Coast milk. Nickel-related cancer risk was found to be higher than the projected lifetime risk for carcinogens in Nunu and Olympic, with 2-3 customers of 1,000 having an elevated lifetime cancer risk. Peak Milk and Three Crown milk have no cancer risks, but Coast and Cowbell have nickel-related cancer risks that are within the permissible range of anticipated lifetime risks for carcinogens, as shown in Table 4.

The cancer risk index of 10^{-6} (1 in 1,000,000) to 10^{-4} (1 in 10,000) represents a minimum acceptable range of predicted lifetime risks for carcinogens. The total hazard index (THI) of heavy metals in canned milk shows that only Peak Milk has a THI less than one ($\text{THI} < 1$). Other kinds of canned milk had a total hazard index greater than 1, with Nunu milk having a hazard value of 3.995. Thus, among the canned milk evaluated, Peak Milk has the lowest overall danger index, whereas Nunu milk has the highest total hazard index (see Table 5).

Table 6 shows the total cancer risks for carcinogenic heavy metals in canned milk. It demonstrates that all canned milk studied have total cancer risks that are below the allowable range of expected lifetime carcinogen hazards (10^{-6}–10^{-4}). Nunu Milk has the greatest total cancer risk of

Table 1: Heavy metal concentrations in canned milk.

Milk types	Lead (ppm)	Cadmium (ppm)	Manganese (ppm)	Nickel (ppm)	Copper (ppm)	Arsenic (ppm)	Iron (ppm)	Zinc (ppm)
Peak Milk	ND	0.0357 ± 0.002	ND	ND	ND	1.8065 ± 0.005	2.5677 ± 0.001	0.1732 ± 0.001
Three Crown	ND	0.1786 ± 0.001	ND	ND	0.0970 ± 0.001	3.6129 ± 0.002	2.5677 ± 0.002	0.2165 ± 0.002
Coast	ND	ND	0.0648 ± 0.001	0.5128 ± 0.002	0.0647 ± 0.004	2.7097 ± 0.002	2.3231 ± 0.004	0.1818 ± 0.001
Nunu	0.2979	0.0357 ± 0.001	0.0648 ± 0.003	0.8205 ± 0.001	0.0323 ± 0.002	1.1290 ± 0.001	2.3231 ± 0.002	0.1905 ± 0.014
Cowbell	−0.1489	ND	0.0648 ± 0.002	0.3077 ± 0.003	0.0323 ± 0.003	2.2581 ± 0.012	3.9127 ± 0.003	0.2165 ± 0.001
Olympic	ND	ND	ND	0.6154 ± 0.003	0.0647 ± 0.002	1.8065 ± 0.002	2.9345 ± 0.001	0.1475 ± 0.001
Permissible limit	0.015	0.005	0.05	0.05	0.05	0.01	0.3	5–15

Values are presented as mean ± standard of triplicate ($n = 3$); ND = not detected.

Table 2: Daily intake of heavy metals in canned milk (mg/kg/day).

Milk	Pb	Cd	As	Zn	Mn	Ni	Cu	Fe
Peak Milk	—	$4.5E-06$	$1.1E-01$	$6.0E-04$	—	—	—	$1.6E-01$
Three Crown	—	$2.2E-05$	$2.2E-01$	$8.0E-04$	—	—	$6.0E-03$	$1.6\ E-01$
Coast	—	—	$1.6E-02$	$6.0E-04$	$2.0E-04$	$3.2E-02$	$4.0E-03$	$1.4\ E-01$
Nunu	$3.7E-03$	$4.5E-06$	$7.1E-02$	$7.0E-04$	$2.0E-04$	$5.1E-02$	$2.0E-03$	$1.4\ E-01$
Cowbell	$-1.8E-03$	—	$1.4E-01$	$8.0E-04$	$2.0E-04$	$1.9E-02$	$2.0E-03$	$2.4\ E-01$
Olympic	—	—	$1.1E-01$	$6.0E-05$	—	$3.8E-02$	$4.0E-03$	$1.8\ E-01$

Table 3: Target hazard quotients (THQs) in canned milk.

Milk	Pb	Cd	As	Zn	Mn	Ni	Cu	Fe
Peak Milk	—	0.004	0.376	0.002	—	—	—	0.229
Three Crown	—	0.022	0.753	0.003	—	—	0.152	0.229
Coast	—	—	0.564	0.002	0.001	1.605	0.101	0.207
Nunu	0.931	0.004	0.235	0.002	0.001	2.565	0.050	0.207
Cowbell	−0.465	—	0.470	0.003	0.001	0.960	0.050	0.349
Olympic	—	—	0.376	0.002	—	1.920	0.101	0.62
THQ	0.466	0.03	2.774	0.014	0.003	7.05	0.454	1.841

THQ < 1 indicates no adverse health effects, while THQ > 1 or $a = 1$ indicates that adverse health effects are likely to occur; — = no health risk.

Table 4: Cancer risk of heavy metals in milk.

Milk	Pb	Cd	Ni	As
Peak Milk	—	$1.7E-06$	—	$1.7E-01$
Three Crown	—	$8.4E-06$	—	$3.4E-01$
Coast	—	—	$3.2E-02$	$2.5E-01$
Nunu	$3.2E-02$	$1.7E-06$	$8.7E-02$	$1.1E-01$
Cowbell	$1.6E-05$	—	$3.2E-02$	$2.1E-01$
Olympic	—	—	$6.5E-02$	$1.7E-01$

Table 5: Total hazard index for canned milk.

Milk	Hazard index (HI)
Peak Milk	0.611
Three Crown	1.29
Coast	2.480
Nunu	3.995
Cowbell	1.368
Olympic	3.019

HI values >1 indicate that there is an increased chance that noncarcinogenic risk may occur, and when HI < 1, the reverse applies.

Table 6: Total cancer risk index of carcinogenic heavy metals in canned milk.

Milk	Total cancer risk
Peak Milk	$1.7E-01$
Three Crown	$3.4E-01$
Coast	$2.8E-01$
Nunu	$1.9E-01$
Cowbell	$2.4E-01$
Olympic	$2.3E-01$

$2.7E-03$, meaning that 3 of 1,000 people may have a higher lifetime risk of acquiring cancer as a result of carcinogenic metals' cumulative effects. Among the canned milk studied, Peak Milk has the lowest total cancer risk.

The total cancer risk index of 10^{-6} (1 in 1,000,000) to 10^{-4} (1 in 10,000) represents a minimum acceptable range of predicted lifetime risks for carcinogens.

3. Discussion

The heavy metals in canned milk consumed in Calabar Metropolis are investigated in this study. This is to completely comprehend the levels at which certain heavy metals in canned milk samples may pose a health concern to humans, as well as to educate the public about the risks of heavy metals consumption. It will also provide an opportunity to make educated choices about what to eat and what not to eat. For example, the high amount of arsenic found in canned milk samples suggests that those who consume contaminated milk on a regular basis may experience health problems. Arsenic is poisonous and has no useful effects on the body; nonetheless, depending on the dose taken, it can induce acute or chronic toxicity. When compared with the permissible limit of arsenic in edible goods, the considerably ($P < 0.05$) high amount of arsenic in canned milk might be attributable to their sources, preservatives, and contamination from the environment where they are stored. Lead toxicity can as well affect sexual hormones, deplete antioxidant enzymes, induce mineral shortage, and even cause death in extreme cases. The level of lead in Nunu and Cowbell milk should be evaluated on a regular basis to ensure that consumers are not at risk of lead and arsenic toxicity due to its negative consequences, which include delayed puberty in women (see Table 1 for data presentation).

The daily iron consumption from all canned milk tested is substantial, which can be linked to the feeding regiment of animals that provide the raw milk. Cowbell milk containing too much iron may damage metabolic functioning. This necessitates a thorough inquiry into raw milk suppliers, preservatives used, cleanliness standards, and storage conditions. Arsenic (As) in canned milk samples can contribute a large amount of arsenic to the body and, if not monitored, can cause poisoning. Individuals with underlying health issues who consume canned milk may gradually enrich their systems with arsenic, potentially leading to chronic poisoning, because their daily intake is closer to the oral reference dose than other sources. The minimal daily intake of zinc and manganese found in canned milk is not enough to cause toxicity (Table 2). However, when paired with daily consumption of metals from canned milk, daily intake of lead, zinc, manganese, nickel, and iron from contaminated milk samples could result in excessive heavy metal absorption, which could produce serious health effects [20].

The near-absence of daily intake of Pb, Mn, and Ni in the Coast, Peak Milk, and Nunu can be attributed to their nondetectable levels. This indicates that individuals that may drink this milk may not be exposed to toxic effects associated with Pb, Ni, and Mn toxicity [28]. Similarly, the low daily intake of cadmium in Nunu, copper in Cowbell, Fe in Peak Milk, and Mn in Coast and Olympic indicates that low or no adverse health outcomes may be possible with their consumption. The low daily intake of zinc, manganese, and iron is not sufficient to elicit toxic effects. However, daily intake of lead, zinc, manganese, nickel, and arsenic, respectively, from other food sources, combined with the daily intake of metals from milk could lead to excess ingestion and could cause adverse health effects [20].

By comparing the daily intake of the chemical with its corresponding oral reference dosage, the target hazard quotients in Table 3 evaluate the noncarcinogenic health risk associated with ingestion of excessive amounts of heavy metal-contaminated canned milk samples. A target hazard quotient of less than one is generally considered safe; however, a hazard quotient of one or more signals that users of this milk may be prone to noncarcinogenic health problems. Only the target hazard quotient of iron was larger than the one in this investigation, indicating that it is unsafe for human consumption due to the toxic consequences of an excessive amount of iron that can be consumed through it.

Due to the lack of low daily intake of cadmium, manganese, nickel, copper, and zinc, consumers are unlikely to experience noncarcinogenic consequences unless additional sources of excess ingestion are present. All canned milk had target hazard quotients of lead and arsenic that were less than one, indicating that there were no adverse health impacts from arsenic and lead toxicity. However, because the target hazard quotient of arsenic and lead in each can of milk can be estimated to be 1, the concentration of arsenic and lead in liquid milk should be evaluated on a frequent basis to avoid consuming an excessive quantity of arsenic and lead.

To avoid excessive lead consumption, the amount of daily ingestions of Nunu, Cowbell, Three Crown, and Coast milk should be minimized, as there is the possibility of absorbing some As and Pb from other food sources such as vegetables and fruits [28] and the environment. Apart from toxicological effects such as cardiotoxicity, haematotoxicity, organ failure, impaired sexual development, and neurological function, lead is a chemical carcinogen with no vital function in living beings [29, 30] (Storelli et al. 2012). The cumulative noncarcinogenic effects of numerous hazardous substances, such as heavy metals, taken by an individual over a period of time are referred to as a "hazard index" (HI).

A hazard index greater than one ($HI > 1$) is thought to suggest that users of products with the hazard index are likely to have significant adverse noncarcinogenic health impacts. These negative health impacts are larger than any of the individual hazardous substances or pollutants that contribute to the observed cumulative effects. As a result, the high value of $HI > 1$ found in Nunu, Three Crown, and Olympic milk implies that these kinds of milk have substantial noncarcinogenic risk effects on their users. To reduce the negative health impacts of heavy metal consumption, this necessitates a reduction in heavy metal consumption. The low hazard index ($HI=1$) seen in Peak Milk can be ascribed to its low heavy metal content and daily intake.

It is demonstrated that the harmful effects of heavy metals found in it are unlikely to cause many noncarcinogenic health problems in users. Heavy metal content, on the other hand, should be closely monitored to ensure that their hazard index remains below one, particularly for Nunu, Three Crown, and Coast, which have hazard indexes close to one.

The cancer risk index of carcinogenic heavy metals in canned milk revealed that As and nickel have significant cancer risks that contribute significantly to the total cancer risks reported [28]. The absence of cadmium-related cancer risks in the Coast, Cowbell, and Olympic milk demonstrated that users of these types are not at risk from cadmium toxicity [23, 31]. The modest cancer risk associated with cadmium toxicity in Peak Milk and Nunu, on the other hand, suggests that 5 of every 100,000 people who consume this milk will have an increased cancer risk over their lifetime. The significant cancer risk associated with nickel toxicity in Nunu, Coast, Three Crown, and Olympic milk is owing to the high nickel level in these types of canned milk, which necessitates nickel reduction. All canned milk samples had a lead cancer risk index that is within the permitted range of carcinogenic chemical lifetime risk. To improve the safety of its consumers, major efforts should be made to lower the arsenic, lead, and nickel content in canned milk from its various stages of manufacturing, transit, and storage. The data are presented in Tables 4 and 5.

Arsenic, cadmium, lead, and nickel contributed to the carcinogenic effects of all metals in the canned milk samples, according to the overall cancer risk index of carcinogenic heavy metals. Individuals who drink this canned milk are likely to have an increased lifetime cancer risk, exactly as the milk risk value above the minimum allowable anticipated range of lifetime risk for carcinogens, according to the overall cancer risk in Three Crown, Coast, Olympic, Nunu, and Cowbell. This means that about 1–8 people of 10,000 and 3 people of 100,000 who consume Three Crown, Olympic, Nunu, and Cowbell canned milk may be at risk for cancer for the rest of their lives due to heavy metals in this milk. Reduced heavy metal concentration in canned milk is critical for lowering cancer risk and total cancer risk. As a result, to protect consumers, all canned milk should be checked for carcinogenic metals and toxicants.

4. Conclusion

According to the conclusions of this study, canned milk sold in the Calabar area has varying quantities of heavy metals, with arsenic, cadmium, nickel, and lead levels exceeding the legal limit in milk with the permissible limits (Cd: 0.003, Ni: 0.05, and Pb: 0.001 ppm), respectively.

Most of the canned milk had no measurable levels of cadmium, copper, lead, nickel, or manganese. Arsenic was identified in all canned milk samples tested, while lead was found in Cowbell and Nunu. Nunu, Coast, Olympic, and Three Crown milk have a higher noncarcinogenic risk than other brands. As a result of the carcinogenic heavy metal concentration of some milk brands, such as arsenic, lead, cadmium, and nickel, users of these milk brands may face an elevated lifelong cancer risk.

Data Availability

Data are included in supplementary information files with the manuscript and are available from the following links: https://www.chemsafetypro.com/Topics/CRA/How_to_Calculate_HHazard_Quotients_(HQ)_and_Risk_Quotients_(RQ).html; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6616343/; https://www.oregon.gov/deq/aq/cao/Documents/CAO-HIQuickLearn.pdf; https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1057.6274~~~~~~~~~~~̂~̂~̂~̂~~~~~~~~~~~amp;rep=rep1~~~~~~~~~~~̂~̂~̂~̂~~~~~~~~~~~amp;type=pdf; https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6862208/

Conflicts of Interest

The author declares no conflicts of interest.

Supplementary Materials

The heavy metals identified in canned milk exhibit significant amounts of lead, cadmium, and arsenic, which are over the allowed limit in Table 1. Except for Peak Milk and Nunu, there were no detectable levels of cadmium in the other canned milk. Lead was found in Nunu and Cowbell, whereas copper (Cu) was found in other canned milk samples but not in Peak Milk. Nickel was not found in Peak or Three Crown milk, but it was found in canned milk. Iron and zinc were found in every canned milk (Table 1). Table 2 shows the amounts of heavy metals consumed each day through canned milk. Nunu, for example, contributed the most to daily heavy metal consumption, despite being below the oral guideline dose. Although some canned milk had a high daily consumption of arsenic, its value was within the oral reference dosage. Nunu milk had lower levels of zinc, manganese, and nickel than their oral reference doses. Nunu milk was found to be the source of excessive daily absorption of arsenic from canned milk. Table 3 shows the target hazard quotients (THQs) of heavy metals in canned milk. Only nickel in Nunu, Three Crown, and Olympic milk had a target hazard quotient greater than 1 ($THQ > 1$) among the canned milk and heavy metals detected. The target hazard quotients for lead in each of the milk types were lower ($THQ < 1$), but by rounding the numbers, each value is not equaled to 1, with Nunu milk being the closest to 1. Target hazard quotients exist for all canned milk with detectable amounts of Cd, Mn, Ni, Cu, As, and Zn. Their combined summation or addition shows that nickel is more predominant with a THQ of 7.05, followed by arsenic at 2.774 and lastly by iron at 1.841. All canned milk contains cancer hazards, according to the cancer risk index of carcinogenic heavy metals in canned milk. Arsenic (As) has a cancer risk that is within the permissible range of projected lifetime carcinogen risks (10^{-6}–10^{-4}). It has been determined that 2-3 people of every 100,000 who consume canned milk have an elevated lifetime cancer risk due to the toxic effects of arsenic (As). Except for Nunu and Cowbell, lead (Pb) is lower in Peak Milk, Three Crown, and Coast milk. Nickel-related cancer risk was found to be higher than the projected lifetime risk for carcinogens in Nunu and Olympic, with 2-3 customers of 1,000 having an elevated lifetime cancer risk. Peak Milk and Three Crown milk have no cancer risks, but Coast and Cowbell have nickel-related cancer risks that are within the permissible range of anticipated lifetime risks for carcinogens (Table 4). The cancer risk index of 10^{-6} (1 in 1,000,000) to 10^{-4} (1 in 10,000) represents a minimum acceptable range of predicted lifetime risks for carcinogens. The total hazard index (THI) of heavy metals in canned milk shows that only Peak Milk has a THI less than one ($\text{THI} < 1$). Other canned milk samples had a total hazard index greater than 1, with Nunu milk having a hazard value of 3.995. Thus, among the canned milk samples evaluated, Peak Milk has the lowest overall danger index, whereas Nunu milk has the highest total hazard index (see Table 5). Table 6 shows the total cancer risks for carcinogenic heavy metals in canned milk. It demonstrates that all kinds of canned milk studied have total cancer risks that are below the allowable range of expected lifetime carcinogen hazards (10^{-6}–10^{-4}). Nunu milk has the highest total cancer risk of $2.7E-03$, meaning that 3 of 1,000 people may have a higher lifetime risk of acquiring cancer as a result of carcinogenic metals' cumulative effects. Among the canned milk studied, Peak Milk has the lowest total cancer risk. (*Supplementary Materials*)

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