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Comparative Evaluation of Metal levels in Canned and Non-Canned soft drinks: An Investigation for Possible Impacts of Metal Cans

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Abstract

The present study is a comparative assessment of selected metal levels in canned and non-canned soft drinks with a view is to ascertaining whether metal cans could be sources of additional metal ions to the beverages packaged in them. A total of twenty four soft drink samples (twelve canned and twelve of their respective non- canned brands) were analysed for Fe, Zn, Cu, Cr, Cd and Pb using standard methods. The results obtained showed overall higher levels of Fe, Zn and Cu in the canned brands– the mean concentrations were respectively 1.213 mg/L, 1.058 mg/L and 0.443 mg/L for the canned samples and 0808mg/L, 0.51mg/L and 0.4175mg/L for the non-canned brands. The concentrations of Cr, Cd and Pb were however found to be higher in the non-canned samples with mean levels of 0.0383mg/L, 0.0108mg/L, and 0.0065mg/L for the non-canned and 0.0217mg/L, 0.0042mg/L and 0.0043mg/L respectively for the canned samples. An assessment of the obtained concentrations on the basis of the WHO and US EPA maximum permissible limits indicated some degrees of contamination in both the canned and non-canned categories.

Keywords: *Metals, soft drinks, beverages, canned, non-canned.*

1. Introduction

The metal contents of foods and drinks have become an issue of great public interest due an increased awareness of their impacts in health and diseases. Some metals, such as copper and iron, are essential to life and play irreplaceable roles in the functioning of critical enzyme systems and other key metabolic functions in human body. Conversely, other metals are xenobiotics, i.e., they have no useful role in human physiology (and most other living organisms) and, even worse, as in the case of lead and mercury, may be toxic even at trace levels of exposure. Even those metals that are essential have the potential to turn harmful at very high levels of exposure; a reflection of a basic tenet of toxicology--"the dose makes the poison."

Metals occur naturally in our environments from where they are mobilized and introduced into our food sources and water supplies. Anthropogenic (manmade) sources account for a large amount of the toxic metals we are exposed to in the modern day. They include mining and smelting activities, coal combustion, fertilizers, pesticides, vehicular emissions, municipal wastes e.t.c. Contamination of food sources by metals may also result from the manufacturing processes, industrial emissions, and packaging/storage materials. Metals are notable for their wide environmental dispersion, their tendency to accumulate in select tissues of the human body and their overall potential to be toxic even at relatively minor levels of exposure.

Human exposure to metals has risen dramatically in the last 50 years as a result of an exponential increase in the use of metals in industrial processes and products [1]. Lately, food packaging has gained widespread importance in food safety due to the possibility of migration of chemicals from food contact materials. The term 'migration' usually describes a diffusion process, which may be strongly influenced by an interaction of the packaging material with the food [2].

In recent years we have witnessed growing consumption of beverages marketed in cans. Metal cans are considered safe, cost effective and environmentally friendly [3]. The metal cans market, is dominated by the beverages industry owing to the high consumption and broad range of products [4].

Food and beverage cans are usually made from two or three pieces of metals. The most widely used metals are aluminium alloy and tin-plated steel. The metal alloys used for cans may contain other elements such as magnesium, silicon, iron, manganese, copper and Zinc, Chromium, Copper, Lead, Nickel, Silver, Tin Titanium Zinc, Cadmium, Cobalt and Mercury because these metals are present as impurities or contaminant in some metallic materials [5]. Recently, the high cost of tin has made attractive the production of Tin-Free Steel (TFS) in which the conventional tin and tin oxide layers are replaced by chromium and chrome oxide layers. There has also been a third system using neither tin nor chromium but nickel as a coating material for the steel base [6]. Although the metal materials used for food canning are often covered by a surface coating which reduces their migration into foodstuffs, when they are not covered these materials can give rise to migration of metal ions into the foodstuffs and therefore could either endanger human health if the total content of the metals exceeds the recommended exposure limits, or bring about an unacceptable change in the composition of the foodstuffs or a deterioration in their organoleptic characteristics [7]. Canned foods may also be subjected to contamination by metals during the canning process; the solder used in manufacture of cans has been recognized as a source of lead during canning [8].

The safety of foods with regards to their contact materials is a vital tool for the control of food quality. Accurate information on sources of metals in foods is important for adequate assessment of their effects on the human health. The objective of this study is to investigate and compare the metal levels of canned and non-canned soft drinks as a preliminary study towards investigating the impacts of metal cans on the beverages packaged in them. This study also evaluates the concentrations of the metals on the basis of their respective permissible limits set by international organisations in order to obtain an insight on the levels of contamination (if any) in the beverages.

To have a good basis for comparison, the samples used for this work were limited to soft drink types

2. Materials and Methods

2.1 Sampling:

A total of twenty four soft drinks samples (twelve canned and twelve of their respective non-canned brands) were bought from retail markets in Zaria, Nigeria. The samples used for this study were limited to the soft drinks brands with the same products marketed in canned and non- canned (i.e. plastic and glass) containers.

2.2 Sample preparation

Wet digestion method was used in the preparation of the samples for metal analysis. 25 ml of each soft drink sample was measured into a clean digestion flask. 10 ml concentrated nitric acid was added, and the mixture was heated on a hot plate until brown fumes disappear. The mixture was allowed to cool and 50 ml of distilled water added. It was then filtered and made up to mark in a 100ml volumetric flask and stored in polyethylene containers prior to analysis.

2.3 Metal Analysis

The digested samples were analysed for the metals Fe, Zn Cu, Cr, Cd, and Pb using Atomic absorption spectrophotometer (Shimadzu AA-6300). Calibration standards for AAS analysis were prepared by serial dilution of concentrated stock solutions (1000 mg/ l) of the respective metals. Five working standard solutions were prepared for each metal. A calibration curve of absorption versus concentration was plotted for each metal and used for the determination of the concentrations in the samples. All analysis were performed in triplicates

3. Results and Discussions

The present work is an attempt at comparing the metal contents of canned and non-canned soft drinks. that have the same brands marketed in cans and other non-can containers. For example, the sample label SD1-CC and SD1-NC indicates the same soft drink type (SD1); the suffix CC indicates the canned brand while the NC suffix indicates non-canned.

Table 1 presents the concentrations of the investigated metals in the canned soft drink samples while table 2 gives the concentrations for their respective non-canned brands. Table 3 presents the maximum permissible limits (MPL) of metals in drinking water as given by World Health organization (WHO) [9] and the US EPA maximum contaminant level (MCL) for same [10]. The recommended limits for drinking water are used as the standard for assessing soft drinks, juices and other water based beverages. Figures 1 and 2 present pictorial comparisons of the mean metal levels in the canned and the non-canned brands.

The Fe contents of the studied beverages ranged between 0.24 - 3.81mg/L in the canned brands and 0.14 – 2.91mg/L in the non-canned brands. The average Fe content was 1.213mg/L for the canned beverages and 0.808mg/L for the non-canned. This indicates higher Fe contents in the canned samples. The maximum contaminant level (MCL) for Fe in drinking water as set by US EPA is 0.30mg/L. Our results show that 75% of the canned samples had iron contents above the MCL while for the non-canned brands, 41.67% had Fe concentrations above the allowed limit.

Table 1: Concentrations of selected metals in the canned the soft drink samples (mg/L)

Sample code	Fe	Zn	Cu	Cr	Pb	Cd
SD1-CC	0.81 ± 0.02	2.42 ± 0.06	0.11 ± 0.01	0.04 ± 0.01	ND	ND
SD2-CC	0.78 ± 0.10	0.82 ± 0.00	0.34 ± 0.02	ND	ND	0.01±0.00
SD3-CC	1.84 ± 0.11	0.85 ± 0.01	0.07 ± 0.01	0.06 ± 0.02	ND	ND
SD4-CC	3.81 ± 0.02	1.92 ± 0.04	0.58 ± 0.03	0.05 ± 0.02	0.01±0.00	0.002±0.00
SD5-CC	1.27 ± 0.03	1.22 ± 0.02	0.38 ± 0.04	ND	0.02±0.01	0.02±0.01
SD6-CC	0.25 ± 0.04	0.08 ± 0.15	0.25 ± 0.03	0.01 ± 0.00	0.01±0.01	0.01±0.01
SD7-CC	1.73 ± 0.40	0.20 ± 0.04	0.26 ± 0.10	0.01 ± 0.00	ND	ND
SD8-CC	0.97 ± 0.02	2.01 ± 0.10	0.51 ± 0.00	ND	ND	ND
SD9-CC	0.24 ± 0.15	0.51 ± 0.06	0.55 ± 0.01	0.05 ± 0.01	0.01±0.00	ND
SD10-CC	1.91 ± 0.45	1.78 ± 0.10	0.64 ± 0.02	ND	ND	ND
SD11-CC	0.67 ± 0.05	0.47 ± 0.04	1.54 ± 0.15	ND	ND	0.01±0.00
SD12-CC	0.27 ± 0.80	0.41 ± 0.03	0.09 ± 0.03	0.04 ± 0.00	ND	ND
Mean conc.	**1.213**	**1.058**	**0.443**	**0.0217**	**0.0042**	**0.0043**

Results for each sample are presented as mean ±SD for three determinations; ND=Not determined

Table 2: Concentrations of selected metals in the non-canned soft drinks samples (mg/L)

Sample code	Fe	Zn	Cu	Cr	Pb	Cd
SD1-NC	0.18 ± 0.07	1.24 ± 0.02	0.20 ± 0.04	0.10 ± 0.02	ND	ND
SD2-NC	1.21 ± 0.05	0.52 ± 0.02	0.23 ± 0.01	0.07 ± 0.03	0.05±0.02	0.03±0.01
SD3-NC	0.17 ± 0.01	0.02 ± 0.00	0.32 ± 0.06	0.03 ± 0.00	ND	0.01±0.00
SD4-NC	1.58 ± 0.04	1.02 ± 0.10	0.15 ± 0.00	0.04 ± 0.01	ND	ND
SD5-NC	2.91 ± 0.12	0.66 ± 0.05	0.43 ± 0.02	0.08 ± 0.02	ND	ND
SD6-NC	0.10 ± 0.03	0.05 ± 0.02	0.18 ± 0.05	ND	ND	ND
SD7-NC	0.24 ± 0.10	0.18 ± 0.01	0.18 ± 0.06	ND	0.01±0.01	0.01±0.00
SD8-NC	0.39 ± 0.20	0.15 ± 0.02	0.38 ± 0.02	0.03 ± 0.00	0.02±0.01	0.003±0.00
SD9-NC	2.30 ± 1.20	1.12 ± 0.02	2.20 ± 0.00	0.06 ± 0.01	0.04±0.01	0.005±0.00
SD10-NC	0.20 ± 0.03	0.25 ± 0.05	0.30 ± 0.08	0.02 ± 0.00	0.01±0.00	0.02±0.01
SD11-NC	0.28 ± 0.00	0.70 ± 0.03	0.08 ± 0.02	0.01 ± 0.01	ND	ND
SD12-NC	0.14 ± 0.02	0.21 ± 0.01	0.36 ± 0.01	0.02 ± 0.00	ND	ND
Mean Conc.	**0.808**	**0.51**	**0.4175**	**0.0383**	**0.0108**	**0.0065**

Results for each sample are presented as mean ±SD for three determinations; ND=Not determined

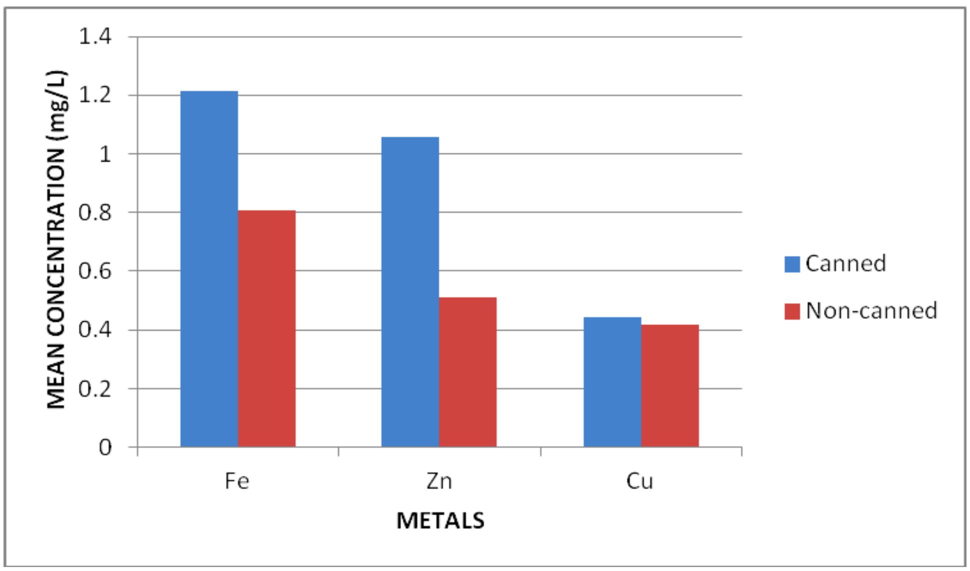

Fig.1. Mean levels of Fe, Zn and Cu in the canned and non-canned softdrinks

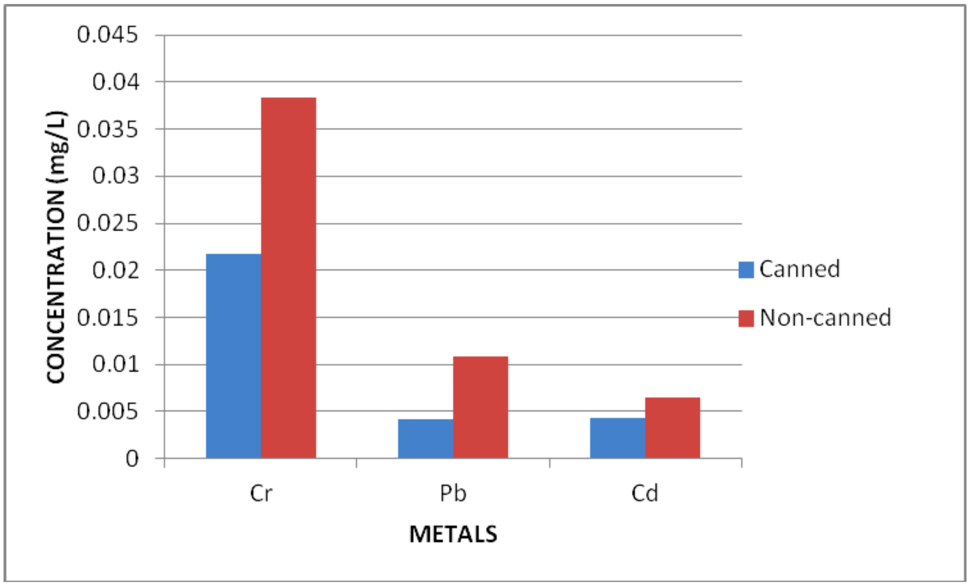

Fig.2. Mean levels of Cr, Pb and Cd in the canned and non-canned softdrinks

The concentration of zinc in the studied beverages was found to range from 0.20 - 2.42mg/L and 0.02-1.24mg/L for the canned and non-canned brands respectively. The average Zn concentration was 1.058mg/L for the canned samples and 0.51mg/L for the non-canned. This shows higher Zn content in the canned brands. The Zn contents of all the samples analysed were below the MCL (5.0mg/L) for Zn.

Copper levels ranged from 0.07-1.54mg/L for the canned and 0.08 - 2.20 mg/L for the non- canned drinks. The mean levels of Cu in the soft drinks were 0.443mg/L and 0.418mg/L for the canned the non-canned respectively. Here the results indicate no significant difference between the overall mean Cu contents of the canned and the non canned brands. WHO recommends a maximum limit of 2.0mg/L of Cu in drinking water while US EPA recommends 1.3mg/L. Among the canned beverages, none of the Cu concentrations exceeded the WHO MPL. However, one sample (SD11-CC) had Cu content above the US EPA limit; this represents 8.3% of the canned samples. For the non-canned beverages, one sample (SD9-NC) was also found to contain Cu in concentration above the allowed limit.

Chromium concentrations in the studied beverages ranged from ND (not determined) to 0.06mg/L for the canned and ND to 0.08mg/l for the non-canned samples. The mean Cr levels were 0.022mg/l and 0.038mg/l for the canned and non-canned respectively. This indicates higher overall Cr content in the non - canned beverages. The maximum admissible limits for Cr in drinking water are 0.05mg/l [9] and 0.1mg/l [10]. 41.6% of the canned samples contained Cr above the safe limit while 75% of the non- canned brands had Cr concentrations above the limits.

Table 3: maximum admissible limits of metals in drinking water [9,10]

Metals	WHO Maximum permissible limit (mg/l)	USEPA Maximum Contaminant levels (Mg/l)
Fe	NGL	0.3
Zn	NGL	5.0
Cu	2.00	1.3
Cr	0.05	0.1
Pb	0.01	0.015
Cd	0.005	0.005

NGL= no guideline, because it occurs in drinking water at concentrations below those at which toxic effects may occur

The concentration of lead in the canned samples ranged from ND - 0.02mg/l and mean concentration was 0.0042mg/l. The non-canned brands showed higher Pb concentration with a range of ND-0.05mg/l and mean concentration of 0.0108mg/l. Among the canned brands, only 1 sample (8.33%) had Pb concentration above safe limits. For the non-canned soft drinks, three samples (25%) exceeded the safe limits for Pb.

Cadmium concentration range of ND - 0.02mg/l was obtained for the canned samples while the concentration for the non-canned ranged from ND-0.03mg/l. The Cd mean levels were 0.0043mg/l and 0.0065mg/l for the canned and non-canned soft drinks respectively. The recommended maximum limit for Cd in drinking water is 0.005mg/l. Our results here show the same levels of contamination by Cd in both the canned and non-canned brands; 33.33% in both groups had Cd levels above the permissible limits.

Previous studies have reported variable differences in the metal contents of canned and non-canned foods and beverages. Maduabuchi et al. [11] reported Fe concentration range of 0.020-2.460mg/l for canned and 0.020-2.090mg/l for non-canned beverages. Their findings showed higher Fe levels in the canned beverages. Other studies have also reported higher Fe levels in canned foods [12, 13]. A study by Orisakwe and other collaborators [14] reported higher copper and zinc contents in canned beverages. The range reported for Cu was 0.04 - 3.55 mg/L and Zn, 0.01 - 1.34 mg/L for canned beverages while for the non-canned samples, Cu range of 0.04 - 3.20 mg/L and Zn , 0.01 - 1.11 mg/L was reported. Some studies however, showed higher Cu and Zn contents in non-canned samples [6, 15]. Higher Cr concentration range of 0.528 - 1.509 mg/L for canned against 0.176 - 1.358 mg/L for non-canned beverages have been reported [15]. Other studies have also established higher Cr concentrations in the canned products [13,16] - these findings are contrary to ours which established higher Cr levels in the non-canned products. Pb and Cd contents have been shown to be higher in canned products in a study by Al-Thagafi et al [13]. They reported mean concentration of Pb as 7.11mg/kg in canned and 2.31mg/kg in the non-canned samples while Cd levels was shown to be 1.64 mg/kg in canned against 0.37mg/kg in the non canned. Overall, the data from literature indicate no definite pattern with regards to the differences in the metal levels of canned and non-canned foods; while some studies showed higher contents of certain metals in canned samples, others recorded lower levels of same metals in similar samples.

4. Conclusions

The results obtained in this study showed overall higher mean levels of Fe, zn and Cu in the canned samples while the levels for Cr, Cd and Pb were higher in the non- canned beverages. Data on similar studies from literature showed varying levels of the metals among the canned and non-canned samples. Our findings indicate that the high metal levels recorded for some canned samples cannot be conclusively attributed to the metal cans because high contents were also recorded among the non-canned samples. This suggests that other factors such as poor water sources and bad production practices may have contributed to the high metal contents obtained for some of the investigated samples. Although leaching of metals from cans into products packaged in them is well recognized and documented, it is however known to be dependent on several factors such pH, duration and temperature of storage, types of additives, presence of oxidants among others. To fully understand the impacts of metal cans vis–à–vis the metal contents of canned food and drinks, there is need for further investigations on the roles of the afore mentioned factors.

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