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Trace metal Levels in Some Packaged Fruit Juices Sold in Makurdi Metropolis Markets, Nigeria

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ABSTRACT

The concentrations of ten (10) trace metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, Se, Cd and Pb) in samples of commonly consumed fruit juices in Nigeria were determined using Atomic Absorption Spectrophotometric (AAS) technique. The mean concentration (mg/L) of the trace metals in the samples analyzed were as follows: Cr (0.172±0.05), Mn (2.29±1.0), Fe (14.4±7.9), Co (0.739±0.29), Ni (0.217±0.17), Cu (0.758±0.47), Zn (1.79±1.3) and Se (0.385±0.25). However, Cd and Pb were below the detection limit of the AAS and therefore not detected in all the juice samples analyzed. The mean concentrations of trace metals in descending order for all the fruit juices samples analyzed was; pineapple > orange > apple. Similarly, the pattern of mean concentrations of trace metals for the six different brands investigated were coded as follows: Ceres (CR) > Chivita (CH) > Fumman (FU) > Frutta (FR) > Soy good (SG) > Nature's fresh (NF). Some of the results obtained were comparable to those found in the literature, but urgent attention is required to address high metal content found in pineapple juice of one brand (CR).

Keywords: Atomic Absorption Spectrophotometric, Fruit Juice, Makurdi, Nigeria, Trace metals.

INTRODUCTION

The rapid growth of industrialization and many activities of humans have resulted in the dispersion of trace metals (heavy metals) in the environment (Borom *et al.*, 2007; Zukowska and Biziuk, 2008). These metals are persistent in the environment and therefore have long biological half lives and bio-accumulate in the body organs, resulting in unwanted health problems (Sobukola *et al.*, 2010). Heavy metals enter the human body through ingestion of food and water, inhalation of air and adsorption through the skin (Yuzbasi *et al.*, 2009). They are significant in nutrition either by their essential nature or their toxicity (Onianwa *et al.,* 1999). They are mobile and are easily taken up by plants in the environment before transmitting it to human body through ingestion. It is known that among many routes, food is one of the main sources of human's exposure to trace metals. They enter the food through sources such as application of chemicals on soil for growing food product, water used in processing, equipments and container used in food processing, storage and packaging and transportation (Yuzbasi *et al.,* 2009).

The increasing demand for food and food safety has drawn the attention of researchers to the risk associated with the consumption of contaminated food materials (Zukowska and Biziuk, 2008). Children are the most vulnerable age group to any kind of contamination in the food chain. Majority of research confirms that 100% juices do not make children overweight (Kellen, 2007). Fruit juices and most drinks usually contain small amounts of essential trace elements, which contribute to dietary intakes, and the levels of these elements need to be controlled (Ikem *et al.*, 2002). Although, some of these elements are important for the normal functions of the body, when their concentrations exceed an allowable amount, they cause acute and chronic poisoning leading to significant illness, reduced quality of life and even death (Senesse *et al.,* 2004).

Various researchers have worked on the nutritional values of fruit juices around the globe (France, Spain, USA, Brazil, China, South Korea, Australia, Malaysia, Iran, Saudi Arabia, Pakistan, South Africa, etc.). Onianwa *et al.* (1999) reported trace heavy metals composition of some Nigerian beverages and food drinks. Trace heavy metal levels of some cubes and food condiments readily consumed in Nigeria have also been reported (Borom *et al*, 2007). Similarly, Maduabuchi *et al* (2008) investigated concentration levels of Fe, Mn and Ni exposure from beverages in Nigeria. Since increased dietary intake of heavy metals contributes to the development of health disorders, it is necessary to constantly monitor these substances in human diets especially on a variety of fruit juices being sold in Nigeria. This will enable us to ascertain whether these products conform to our national and international standards as it affects the health of these populations.

MATERIALS AND METHODS

Sampling: Six different (6) brands of commercial fruit juice (Apple, Pineapple and Orange) were obtained from Supermarkets within Makurdi metropolis and coded: **CR, CH, NF, FU, FR** and **SG.** One hundred and eighty (180) fruit juice samples of 1.0 litre each were obtained and analyzed prior to their expiration dates. Wet digestion method was employed in the analysis. $100cm^3$ of the homogenized samples were treated with 5mL each of conc. HNO_3, conc. H_2SO_4 and heated for an hour at regulated temperature of 120^oC. The digested samples were cooled and diluted to 100 mL volume with distilled de-ionized water and kept in polyethylene sample container ready for AAS analysis. Each experiment was repeated in triplicate. Analytical grade salts of metals under investigation were used to prepared standard solutions for calibration curves.

RESULTS AND DISCUSSION.

The mean concentration of ten (10) trace metals analyzed in the fruit juices (apple, pineapple and orange) are presented in Table 1. Generally, the concentration of Fe was the highest in all samples irrespective of fruits and brand, while that of Ni was the lowest. However, Pb appeared once and Cd was not detected in all the samples analyzed. The graphical representations of levels of heavy metals in six different brands are presented in Figs. 1 – 6.

Apple: The mean concentration of all heavy metals present in apple juice was 2.08mg/L in all the six different brands. The highest concentration was found in **CR** brand (2.95mg/L) while the least was **NF** with a value of 1.09mg/L. The recommended daily intakes of metal from apple juices vary from 0.67µg of Cr to 14.93µg of Zn. The concentration level of trace metals in apple juice was the least among the three juices considered. Even though, the apple concentration obtained in this work is higher than recommended value of 0.2mg/L by WHO (1993).

Pineapple: The pineapple juice was ranked first in respect of trace metals concentration among the three fruit juices investigated. The mean concentration of all trace metals present in pineapple juices was 3.20mg/L in all the six different brands. The highest concentration was found **CH** brand (4.59mg/L) while the least was **NF** with a value of 2.14mg/L. The recommended daily intakes of metal from pineapple juices vary from 0.59µg of Cr to 25.25µg of Zn (WHO, 1993).

Table 1: Concentration of Trace Metals in Some Selected Fruit Juices

Element	Fruit Juices (mg/L)		
	Apple	Pineapple	Orange
Cr	0.142	0.207	0.170
Mn	1.56	3.11	2.50
Fe	12.8	16.1	14.2
Co	0.681	0.788	0.748
Ni	0.0957	0.309	0.247
Cu	0.417	0.951	0.907
Zn	0.695	2.49	2.19
Se	0.267	0.526	0.364
Cd	ND	ND	ND
Pb	ND	0.002	ND

ND: Not detected.

Orange: The mean concentration of all trace metals present in orange juices was 2.67mg/L in all the six different brands. The highest concentration was found **CR** brand (3.48mg/L) while the least was **NF** with a value of 1.67mg/L. The recommended daily intakes of metal from orange juices vary from 0.63µg of Cr to 14.3µg of Zn (WHO, 1993). The mean values obtained in this work for all the trace metals was by a factor of 10 higher than literature values reported by Onianwa *et al* (1999).

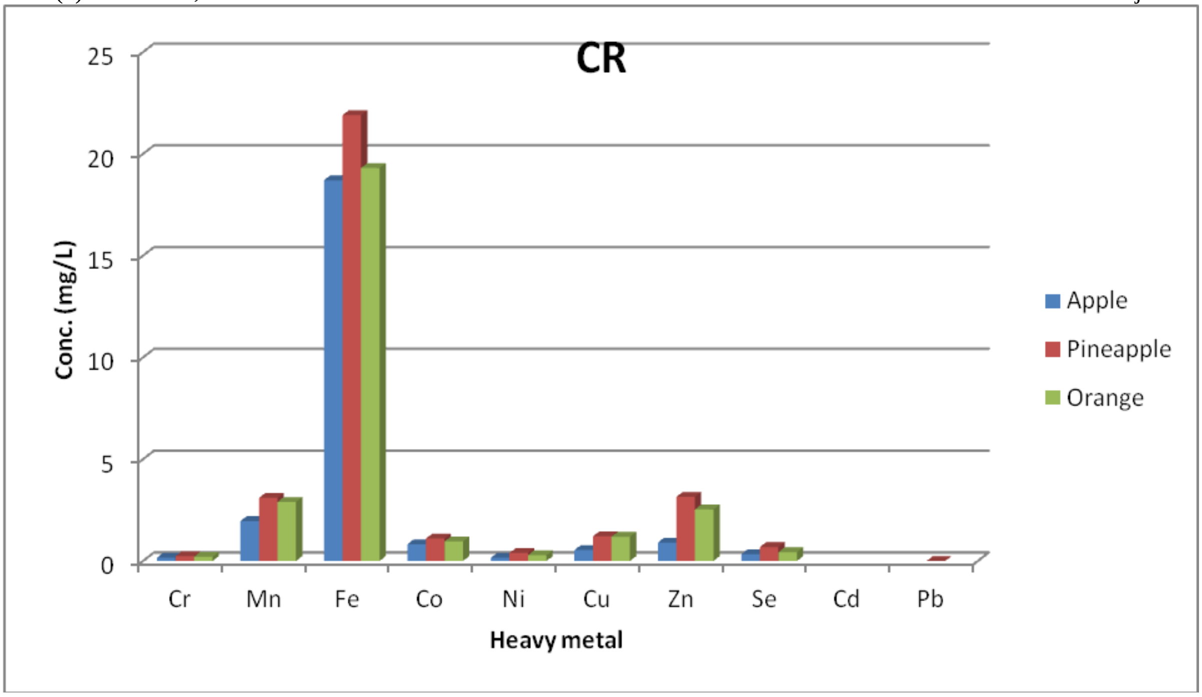

Fig1. Mean Concentration of Trace Metals in CR Fruit Juices.

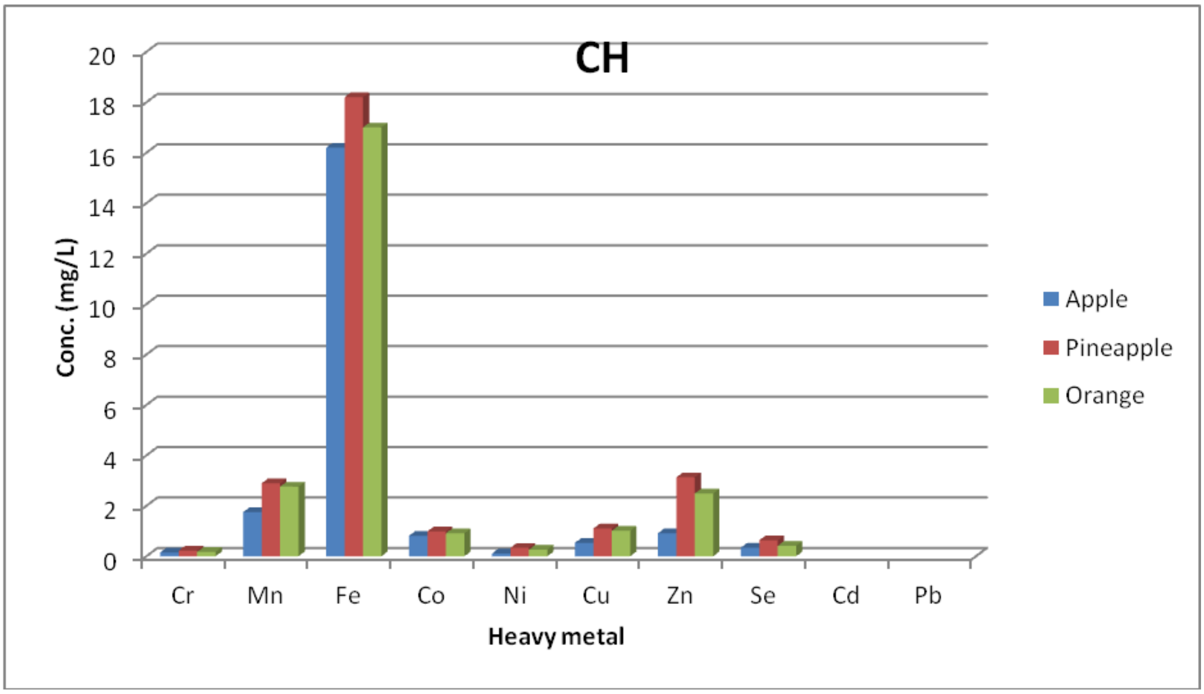

Fig 2. Mean Concentration of Trace Metals in CH Fruit Juices.

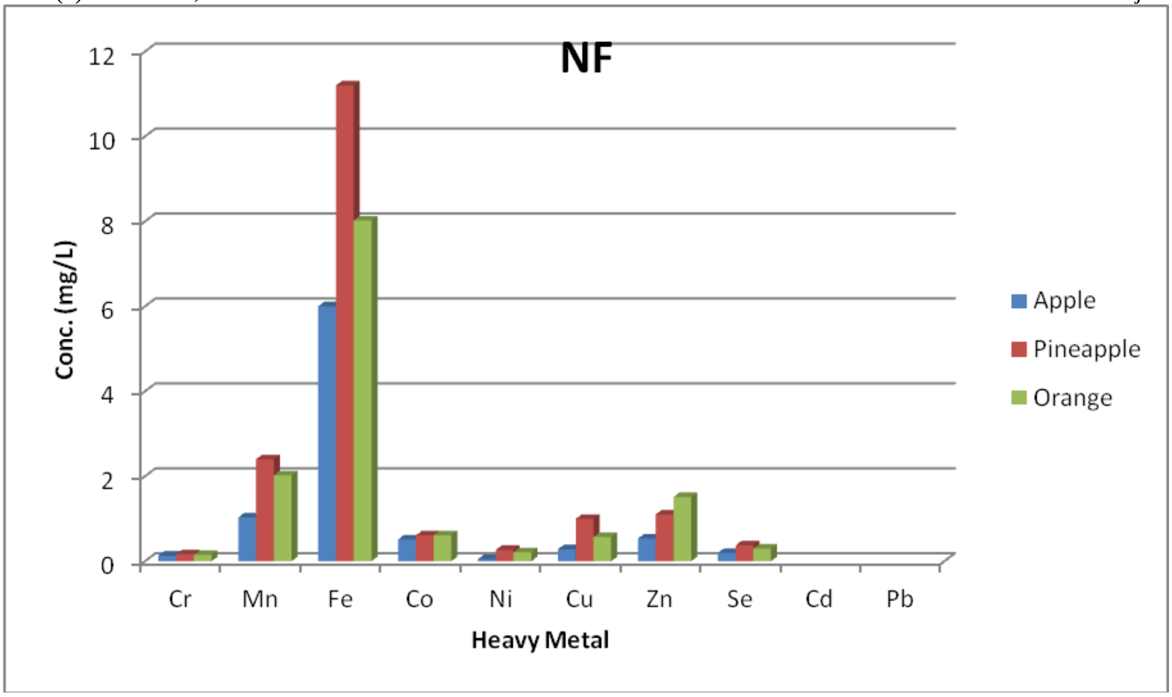

Fig 3. Mean Concentration of Trace Metals in NF Fruit Juices.

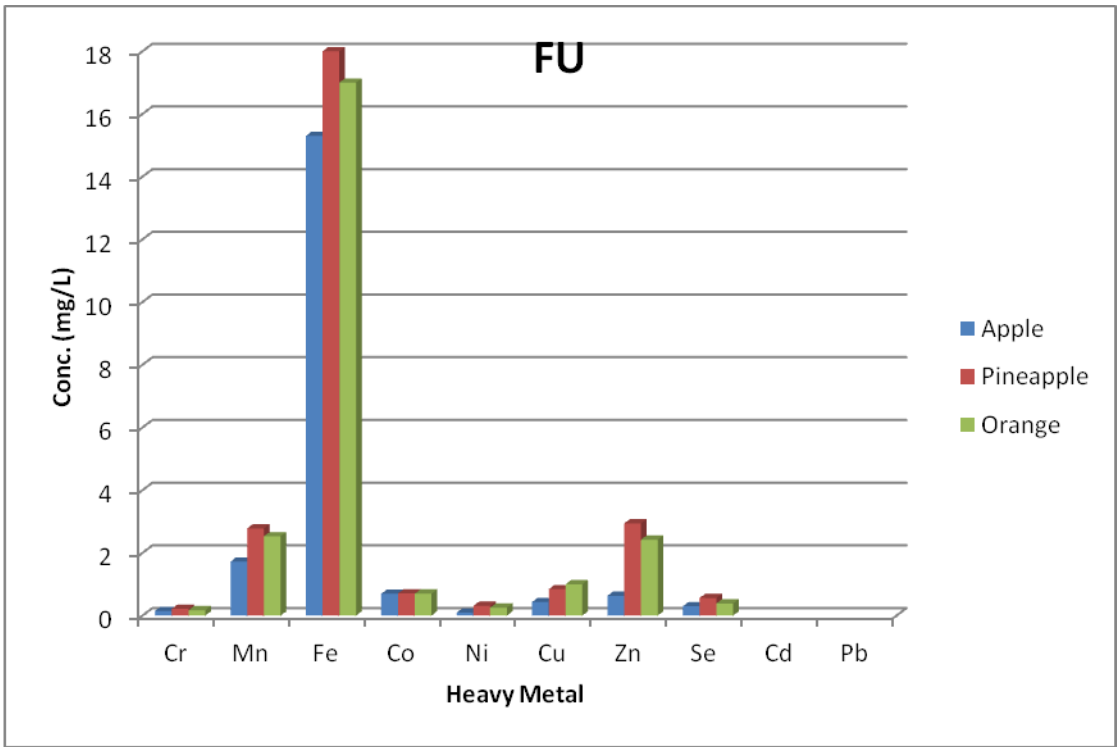

Fig 4. Mean Concentration of Trace Metals in FU Fruit Juices.

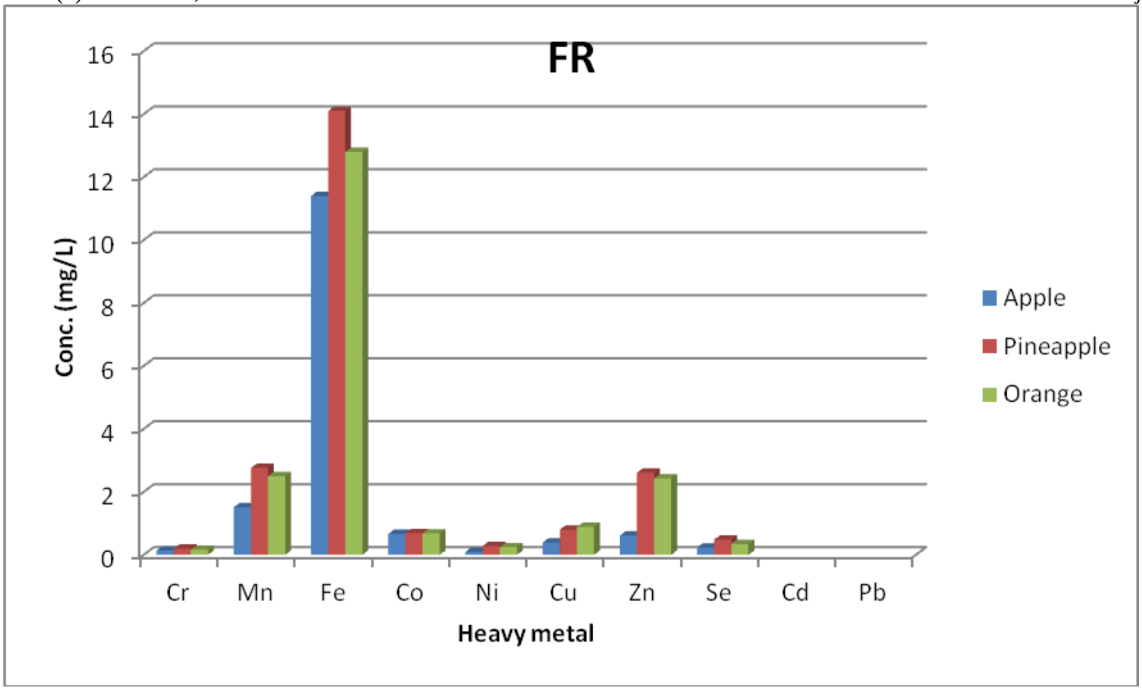

Fig 5. Mean Concentration of Trace Metals in FR Fruit Juices.

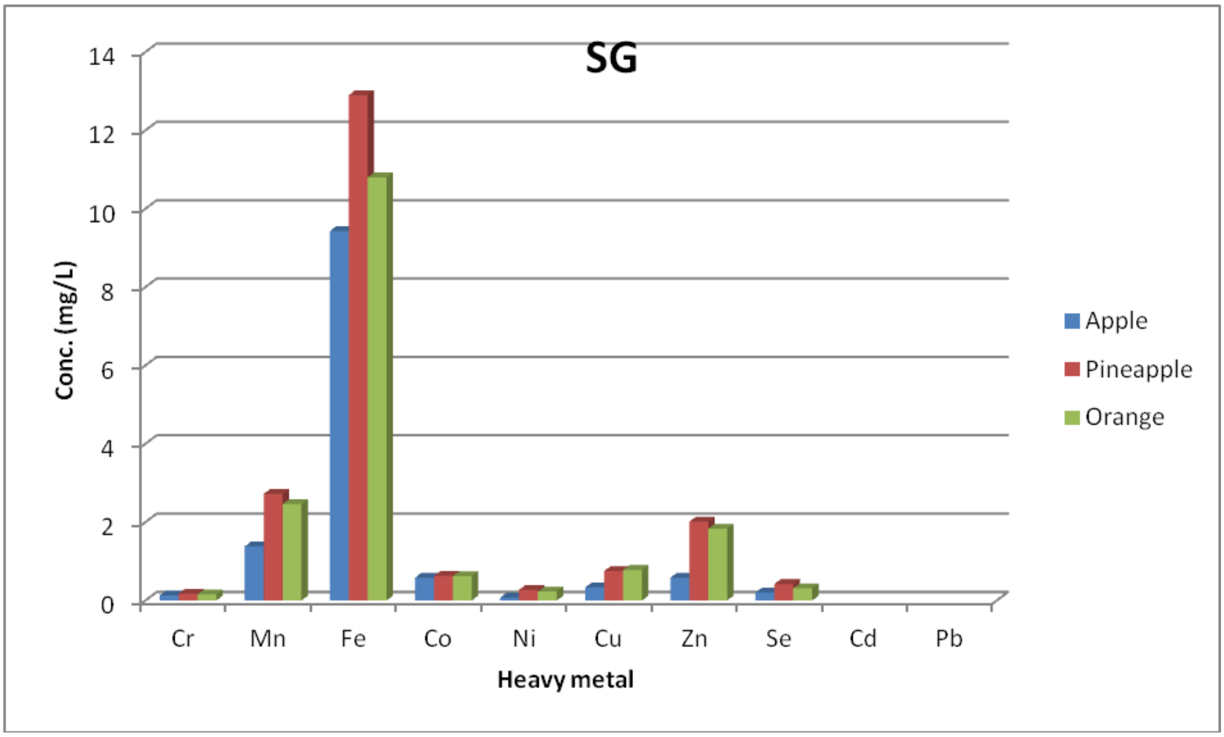

Fig 6. Mean Concentration of Trace Metals in SG Fruit Juices.

Cr is commonly found in foodstuffs, as it enhances the action of insulin and functions in mammalian glucose metabolism which is very vital to humans (Hardy et al., 2008). The mean concentration of all trace metals present in fruit juices was 0.172 ± 0.05 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (0.237 mg/L) while the least was **SG** apple with a value of 0.129 mg/L. The recommended daily intake of Cr is between 0.025 and 0.2mg/day (CAC, 1995). The maximum limit in drinking water is 0.05mg/L of Cr (VI) (WHO, 1993). The speciation of Cr is of great importance for the toxicity because Cr (III) is an essential element for normal glucose metabolism while Cr (VI) is highly toxic (Costa, 1997). Effects of Cr toxicity to humans are: ulcer, convulsion, kidney and liver disorder, cancer and renal failure.

Mn is an essential trace element that plays a role in bone mineralization, protein and energy metabolism, metabolic regulation, cellular protection from damaging free radical species and the formation of glycosaminoglycans (ATSDR, 1997). Insufficient of Mn in the body can result in anaemia while its accumulation in humans results to gastrointestinal disorder, cancer, respiratory problem (Blaurock, 2009). The mean concentration of all trace metals present in fruit juices was 2.29 ± 1.0 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (3.10 mg/L) while the least was **NF** apple with a value of 1.03 mg/L. The recommended daily intake of Mn to between 2 – 3mg/day and provisional health-based guideline value of 0.5mg/L for drinking water (WHO, 1993).

Fe is core component of the red blood cells which is present in most foods and beverages. Its deficiency can cause anemia. Fe fortification in food has been increased to tackle the increased incidence anemia especially in western countries (Maduabuachi *et al*., 2008). The mean concentration of all trace metals present in fruit juices was 14.4 ± 7.9 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (21.9 mg/L) while the least was **NF** apple with a value of 6.00 mg/L. Ingestion of soluble Fe salts by children in doses exceeding 0.5g of Fe can give rise to severe lesions in the gastrointestinal tract, followed by metabolic acidosis, shock and toxic hepatitis (Elinder, 1986).

Co usually combines with vitamin B12 consistently in the body. Its deficiency is rare in human but cattle are seen affected with symptoms like anaemia. The mean concentration of all trace metals present in fruit juices was 0.739 ± 0.29 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (1.10 mg/L) while the least was **NF** apple with a value of 0.512 mg/L. The daily recommended range of cobalt in human diet is 0.005mg/day (ATSDR, 2004). Co intakes > 30mg/day can cause digestive and skin disorders in humans. An annual investigation on Co shows that protein deficiency mainly tryptophan can cause Co toxicity in the body (COMA, 1991).

Ni plays an important role in biological system such as enzymes activities in hormonal control and in RNA, DNA and protein structural function. Symptoms of Ni toxicity include dizziness, short and rapid respiration and cyanosis (Kairvelu, 2000). It is found in small quantities in many foodstuffs (0.001 – 0.01 mg/kg) and in higher concentrations in foodstuffs such as grains, nuts, cocoa products and seeds (up to 0.8 mg/kg). The mean concentration of all trace metals present in fruit juices was 0.217 ± 0.17 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (0.391 mg/L) while the least was **NF** apple with a value of 0.051mg/L. The daily intake of Ni via foodstuff is estimated at 0.15 – 0.7 mg/day (CAC, 1995). WHO (1997) set a provisional health-based guideline value at 0.2 mg/L for drinking water.

Cu is an essential trace element required (as cofactor in different oxidative and reductive enzymes) for proper health and its high uptake in fruits and vegetable could be harmful for human health and in the same way, the lower uptake in human consumption can cause a number of symptom such as skin ailments, gastrointestinal disorder etc. The mean concentration of all heavy metals present in fruit juices was 0.758 ± 0.47 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (1.21 mg/L) while the least was **NF** apple with a value of 0.282 mg/L. The daily recommended amount of Cu for dietary consumption is 10 ppm (Nair *et al*, 1997).WHO (1998) set a provisional health – based guideline value for Cu at 2.0mg/L in drinking water as a result of uncertainties in the dose-response relationship between Cu in drinking water and acute gastrointestinal effects in human. Cu absorption can be deficient in human body because of excessive Fe and Zn (Gerbasi *et al*, 2003).

Zn is the most common essential element for both plant and animals but may be toxic at high concentrations. Zn may enter foodstuff from by mineralization, food processing or agricultural contamination. The mean concentration of all trace metals present in fruit juices was 1.79 ± 1.3 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (3.15mg/L) while the least was **NF** apple with a value of 0.532mg/L. The required daily intake of Zn for adults is about 15 mg/day, although, the requirement varies with age (JECFA, 1982). WHO (1998) stated that derivation of a health – based guideline value for drinking water is not required. However, drinking water containing Zn levels above 5.0mg/L may be acceptable to consumers. Zn deficiency causes anemia, retarded growth, dermatitis and low immunity. Nutritional sources of Zn such as legumes, eggs, seafood, nuts, grains and vegetables should be encouraged. Excess amount of Zn also results in toxicity which if left untreated can precipitate serious health problem such as anemia, brain damage, kidney problem etc (INECAR, 2000)

Se is nutritional essential for humans needed in the diet on a daily basis, but only in very small amounts (≤5μg). The mean concentration of all trace metals present in fruit juices was 0.385 ± 0.25 mg/L in all the six different brands. The highest concentration was found **CR** brand pineapple (0.682 mg/L) while the least was **NF** apple with a value of 0.193mg/L. It is a constituent of more than two dozen selenoproteins that play critical role in reproduction, DNA synthesis and thyroid hormone metabolism. Deficiency symptoms for Se are difficult to determine and controversial in the literature. However, severe Se deficiency is accompanied severally malnutrition, symptoms can include weakness or pain in the muscles, discoloration of hair or skin, and whitening of the fingernail beds.

CONCLUSION

The pattern of mean concentrations of trace metals was **pineapple > orange > apple**, in respect of fruit juices. Similarly, the pattern of mean concentrations of trace metals in the six different brands was as follows: **CR > CH > FU > FR > SG > NF**. The daily diet fruit juices have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke and some other chronic ailment (Goldberg, 2003). The concentration of trace metals observed in these samples may be attributed to trace metals level in raw materials used which may have a link with soil environment where these raw materials were grown. The source and nature of water purification used and quality control procedures could also contribute to the concentration of trace metal in the samples.

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