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Determination of some soft drink constituents and contamination by some heavy metals in Nigeria

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ABSTRACT

Soft drinks are consumed daily in Nigeria due to its affordability, characteristic taste, and thirst quenching potential. However, the high demand may compromise the quality of production with possible contamination of heavy metals which have shown to cause intoxication and death in humans. This study evaluated some constituents of twenty-six soft drinks in Nigeria and investigated the presence of some heavy metal contaminants. The soft drinks were screened for the presence of sugar, carbon dioxide, phosphate and alcohol as well as the pH and acidity determined. The level of cadmium, mercury and lead were determined using atomic absorption spectrophotometer. The study showed the presence of sugar, carbon dioxide, phosphate, and alcohol in the soft drinks. The soft drinks were acidic in nature, pH ranging from 3 to 5 with a mean of 3.6 and the acid concentration was relatively low between 3 and 12 g/L with a mean of 8.1 g/L. Lead was present in all the samples ranging from 0.17 to 3.39 mg/L with a mean of 0.8, mercury was present in 22 samples ranging from 0.29 to 11.32 mg/L with a mean of 2.08 mg/L while cadmium was present only in one sample (0.149 mg/L). When compared to EPA, WHO and NIS standards, the levels of the heavy metal contaminants were above the tolerated limits for good quality drinking water in most samples. These results suggest that soft drinks in Nigeria may be contaminated with heavy metals which constitute a major public health problem. Thus, quality control is recommended during the production process especially at the stages of sterilization and purification.

1. Introduction

In Nigeria today, soft drink is one of the most consumed beverages. The consumption of non-alcoholic beverages in Nigeria was rated at 159.85 g/person/day in 2007 [1]. Soft drinks exist in various forms and brands and are marketed by different brewery industries across the country [2,3]. These drinks are readily consumed on daily bases especially when undergoing tedious activities like hard work and sport [4]. Also, with the relatively affordable prices, they are highly consumed during leisure and relaxation outings and serve the general public in celebrations such as traditional marriages, weddings, funerals, etc. [5].

The high consumption rate of soft drink is attributed to the characteristic taste and flavour as well as their thirst quenching potential [6]. These characteristics are defined

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by the constituents present such as sugar which is responsible for its sweetness, carbonated water which is water compressed with carbon dioxide to make it an ultimate thirst quencher and flavouring agents to add flavour to the drinks [7]. In addition to taste satisfaction, soft drinks contain other constituents such as vitamins, phosphates, acids, antioxidants, etc. which are of nutritional and health benefits to the body [8].

However, due to the high level of consumption and demand of soft drinks, quality control within the process of production especially during sterilization and purification may be compromised and the quality of soft drinks may be challenging. As such, soft drinks have been shown to contain traces of alcohols as a result of microbial contamination [9]. Also, the presence of some heavy metals such as cadmium, lead, mercury arsenic, zinc, etc. in soft drinks which may be due to environmental pollution from surface and underground water, food and fruits utilized during production have been reported [10].

Heavy metals are metals that have shown to be harmful and toxic to the human body [11,12] and constitute a major public health concern [13,14]. These metals have the potential of causing acute and chronic toxicity by various modes of action in both children and adults [15,16]. Some heavy metals act as catalyst in oxidative reactions of biological macromolecules, therefore their intoxication may lead to oxidative tissue damage [17]. Others have genotoxic/carcinogenic potential causing chromosomal aberrations and mutation as well as cancer [18]. One of the major mechanisms by which heavy metals exert toxic effect is through impairment of cellular respiration by inhibition of various mitochondrial enzymes, and the uncoupling of oxidative phosphorylation [19–21]. Some of the heavy metals of health importance include: cadmium, lead, mercury, etc.

Cadmium is a heavy metal whose long term accumulation may lead to cancer since it is a carcinogenic element [18]. Also, over a long period of intake, cadmium may accumulate in the kidney and liver because of its long biological half life and may lead to kidney damage [22]. Lead is known to affect humans and animals of all ages but the effects of lead are most serious in young children [23]. The most common childhood presentation of lead poisoning is central neurotoxicity [24]. Other symptoms of childhood lead toxicity include; anaemia, peripheral motor neuropathy, gastrointestinal complaints such as anorexia, vomiting, and abdominal pain, and growth delay [25]. Mercury is also another critical health hazard. Its intoxication can occur in infants and adults and has shown to interfere with numerous cellular processes including protein and nucleic acid synthesis, oxidative stress, calcium homeostasis, and protein phosphorylation [26].

Thus, this study was aimed to evaluate some constituents of soft drinks in Nigeria which may be characteristic of their taste and consumption and also assessed some heavy metal for possible contamination.

2. Materials and methods

Twenty-six soft drinks were purchased from local grocery stores in the commercial city of Enugu, Enugu State of Nigeria and were qualitatively analyzed for the presence of sugar, carbon dioxide, alcohol and phosphate while the acidity, pH, and heavy metals concentration were quantified. The presence of sugar, carbon dioxide, phosphates and acidity were determined according to the procedures of AOAC [27].

2.1. Test for sugar

Benedict solution was used to test for the presence of sugar. In this procedure, 3 ml of the sample of different brands were taken into a test tube and 2 ml of Benedict reagent was added. The test tube was heated in a water bath for 5 min and the formation of reddish colour confirmed the presence of sugar in soft drinks.

2.2. Test for reducing sugar

The presence of reducing sugar was tested using Fehling solution. In this test, 3 ml of the sample was taken in a test tube and 2 ml of a mixture of Fehling's A and Fehling's B solutions in equal amount was added. The test tube was heated in a water bath for 10 min and the appearance of brown precipitation confirmed the presence of reducing sugar.

2.3. Test for phosphates

3 ml of sample for each brand of soft drinks was taken into separate test tubes. 2 ml of ammonium molybdate followed by 2 ml of concentrated nitric acid (HNO_3) was added. The solution was heated in a water bath for 10 min and appearance of canary-yellow precipitate confirmed the presence of phosphate ions in soft drinks.

2.4. Test for alcohol

3 ml of sample for each brand of soft drink was transferred into a separate test tube. 1 ml of iodine was added, followed by 1 ml of potassium iodide and 1 ml of sodium hydroxide (NAOH) solution. The test tubes were boiled at 100 °C in a water bath for 30 min. Appearance of yellow coloured precipitate confirmed the presence of alcohol in soft drinks.

2.5. Test for carbon dioxide

As soon as the bottles were opened, 3 ml of the sample for each brand of soft drinks was added to 2 ml of lime water (calcium hydroxide). The change of lime water from colourless to milky confirmed the presence of dissolved carbon dioxide in the soft drinks.

2.6. Quantification of acid concentration

The acidity of the soft drinks was done by the acid titration method. 1 ml of 0.1 M sodium hydroxide was added into a 25 ml capacity burette. 10 ml of the prepared sample was added followed by 2 drops of 1% phenolphthalein. Small amount of the sample was further titrated until the end point was attained marked by a colour changed from