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Applied Chemistry

Elixir Appl. Chem. 41 (2011) 5969-5971

ISSN: 2229-712X

Determination of some trace elements in soft drinks from Ghana using INAA method

Ameyaw F[1], Ayivor JE[1], Debrah SK[2], Dzide S[1], Opata NS[1] and Sarfo Kantanka D[3]

[1]National Reactors Research Centre, Ghana Atomic Energy Commission, P.O. Box LG 80, Legon, Accra, Ghana

[2]Graduate School of Nuclear and Allied Science, P.O. Box AE1, Accra, Ghana.

[3]Nuclear Chemistry and Environmental Research Centre, Ghana Atomic Energy Commission, P. O. Box LG 80, Legon, Accra, Ghana.

ARTICLE INFO

Article history:

Received: 6 October 2011;

Received in revised form:

17 December 2011;

Accepted: 26 December 2011;

Keywords

INAA,

Fruit Juices,

Carbonated Drinks,

Trace element.

ABSTRACT

The purpose of this study was to determine the levels of trace elements in some selected fruit juices and carbonated beverages purchased in Accra metropolis, Ghana. The technique used in this study was Instrumental neutron activation analysis (INAA). Fruit juices considered in this study includes pineapple, strawberry, lemon and orange. Some carbonated drinks were also analysed in this analysis. The trace elements considered were Al, Br, Ca, Cl, Mg, Mn, Na, K, Cd, Co, and As. Generally, the trace elements in the fruit juices were found to be more than that of the carbonated beverages. As, Cd, Co and Br were not detected in any of the samples analysed. Also Ca, Mg, Mn were not present in all the carbonated drinks studied. The levels of trace elements in both the fruit juices and carbonated drinks were however within permissible levels.

Introduction

There has been an increase in the trend of consumption of carbonated and fruit drinks in Ghana. This could be related to the increase in its sales on the streets and increasing number of restaurants and fast foods joints. Usually the constituents of the drinks are mainly water, carbon dioxide (in the case of carbonated drinks), and syrup that characterizes the flavor of the drink. [1] Due to the recent spate in the consumption of these soft drinks, it has become particularly important to determine the elemental contents of these drinks for quality control purposes in as much as soft drinks constitute a significant proportion of trace elements daily intake. [2] In the present era of industrialization and development, one of the issues to be concerned with is the health of the future generation. [3] The manufacture of these soft drinks thus require special attention. Most soft drinks usually contain a certain amount of essentials and potentially toxic trace elements which contribute to the dietary intake of trace elements, and these levels need to be controlled.

The gastrointestinal tract of humans is exposed to various environmental pollutants including trace metals that contaminate food and water that may have adverse effects on the body. Although about 70% of diseases are caused by biological agents, heavy metals also have adverse effects on human health and the toxicity of certain heavy metals like Pb, Cd, As are well established [4].Trace elements in soft drinks may be as a result of environmental contamination, industrial activities and can also be natural from the fruits used to prepare them and also their packaging materials. Trace elements are involved in several processes in the human body including maintaining normal metabolism of glucose, prevention of anemia etc. [5, 6]

INAA is a multi elemental technique suitable for this present work. INAA was used for the analysis of carbonated and non carbonated soft drinks sold on the Ghanaian market. The main aim of this work is to determine the levels of some trace elements in these soft drinks and to assess whether or not the levels present in the drinks are in agreement with world health organization recommended levels.

Materials and Methods

Samples were purchased in the Accra metropolis, Ghana at four different markets and analyzed. The brand names of the fruit juices were labeled brand1, brand2, brand3, and brand4 respectively. The carbonated beverage samples analyzed were similarly labeled beverage1, beverage2, beverage3, and beverage4. Trace metal levels in selected fruit juices and carbonated beverages were determined using Instrumental Neutron Activation Analysis (INAA) method. Fruit juices were pipetted and 0.5 g weighed directly into a pre-cleaned smaller polyethelyn vials heat sealed and packed into irradiation capsules and heat sealed.

Three replicates of each sample and standard reference material were prepared. The reference material was analyzed to validate the technique of analysis. The prepared samples were sent through the pneumatic rabbit system, operating at a pressure of 0.6 MPa within the inner channel of a 30 kW Miniature Neutron Source Reactor (MNSR) for 1 hr at a neutron flux of 5x1011 neutrons/cm2/s. The irradiated samples were left to decay for 24 hours in order to minimize exposure risk and also to eliminate all interferences from short-lived radionuclide and medium-lived elements.

For short lived element, samples were irradiated for 2 minutes.

Each sample was counted for 10 min on a liquid nitrogen cooled High Purity Germanium detector connected to gamma spectroscopy accumulation software, ORTEC MAESTRO – 32. Carbonated beverages were weighed in the same way as the fruit juices and analyzed after irradiation for the trace elements of interest.

Tele:

E-mail addresses: fafeknoc@yahoo.co.uk

Results and Discussions

Arsenic, Cadmium, Bromine and Cobalt were not detected in all the samples considered. This may be because it was not present in the sample or below the detection limit of the technique used. The trace elements in the fruit juices were found to be more than that of the carbonated beverages. Aluminium (Al) is considered as a non essential element. Dietary intake of Al, estimated to be in the range of 0.10 – 0.12 mg Al/kg/day in adults. [7] Increased oral Al absorption has been suggested in Alzheimer's disease (AD) and Down's subjects. Al toxicity was also implicated in a variety of haematological disorders [8, 9]. Yuan et al. (1989) assessed the prevalence of Al associated anemia in an outpatient dialysis population [10]. The highest concentration of Al was seen in a lemon based fruit juice with a concentration of 13.74 mg/kg. Tables 1 and 2 highlight the concentrations of the trace elements in the selected fruit juices and carbonated drinks.

The highest concentration of Ca was 27.74 mg/kg which was seen in the lemon fruit juice studied. It's been recognized that Ca is a macro element that is present in the body at relatively large quantities. The bulk of the Ca concentration is seen in the bones and teeth. [11] Ca in the serum regulates blood clotting, muscle contraction etc. Insufficient dietary Ca increases the risk factors for osteoporosis. [12, 13]

Electrolytes are minerals found naturally in the body, such as Potassium (K), chlorine (Cl) and Sodium (Na). Electrolytes are needed to keep the body's balance of fluids at the proper level and to maintain normal functions, such as heart rhythm, muscle contraction, and brain function. [14] Sodium Potassium and Chlorine were present in both the fruit juices and the carbonated drinks. Except CK2 and VS which did not contain Potassium. The quantitative distribution of Na, K, and Cl in the samples is shown in Figure 1.

Intake of high levels of Mn may cause psychiatric disorders which include difficulty in speech and some compulsive behaviors. [15] The distribution of Mn in the fruit juices is shown in figure 2. Magnesium is well known as an essential element known to play an important role in some enzymes that are involved in some oxidative processes in the human body. The mean concentration of this element in the fruit juices was 0.76 mg/kg; moreover, Mn was not detected in carbonated drinks. A presentation of the variation of Magnesium (Mg) in the fruit juices is shown in figure 3.

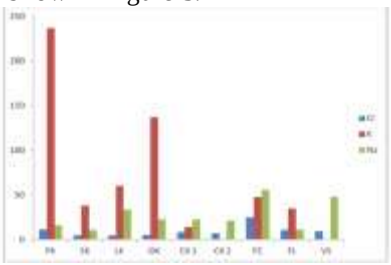

Figure 1: Concentrations (mg/kg) of Cl, K, and Na in the Soft drinks

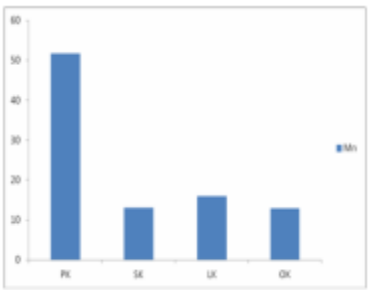

Figure 2: Concentration of Mn in Samples (mg/kg)

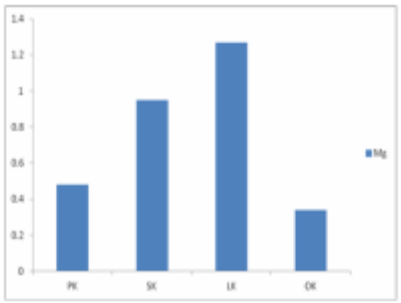

Figure 3: Concentration of Mg in sample (mg/kg)

Conclusions

Instrumental neutron activation analysis has several advantages as a simultaneous multi elemental determination technique and has good analytical features for elemental analysis in both carbonated and non-carbonated drinks. Further study about this subject is necessary to cover all available drinks on the market and also their containers to assess the sources of the various elements to ascertain whether their presence is by leaching from containers, industrial processing or naturally from the fruits used in the preparation of these drinks.

Acknowledgement

The authors are grateful to the staff at the national reactors research centre of the Ghana Atomic Energy commission.

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Table 1 Concentrations of elements in Fruit juices

Sample ID	Discription	Al	Ca	Cl	Mg	Mn	K	Na
PK	Pineaple Base	10.66 ± 0.09	17.82 ± 1.33	11.07 ± 0.63	0.48 ± 0.04	51.74 ± 2.44	237.1 ± 10.91	15.79 ± 0.22
SK	Strawberry Base	13.10 ± 0.11	11.41 ± 1.11	4.70 ± 0.40	0.95 ±0.06	13.05 ± 1.33	37.91± 3.21	10.52 ± 0.18
LK	Lemon Base	13.74 ± 1.23	27.74 ± 2.70	4.74 ± 0.04	1.27 ± 0.09	15.90 ± 1.50	60.13 ± 5.08	33.52 ± 0.31
OK	Orange Base	12.96 ± 1.22	20.70 ± 1.60	4.89 ± 0.06	0.34 ± 0.02	12.92 ± 1.12	136.8 ± 8.04	22.64 ± 0.28

Table 2 concentrations of elements in carbonated beverages

Sample ID	Al	Ca	Cl	Mg	Mn	K	Na
CK 1	11.99 ± 0.23	ND	8.36 ± 0.50	ND	ND	14.13 ± 0.15	22.53 ± 0.32
CK 2	7.5 ± 0.17	ND	6.86 ± 0.44	ND	ND	BDL	21.02 ± 0.30
FC	12.52 ± 0.25	ND	24.66 ± 0.79	ND	ND	47.49 ± 4.27	55.31 ± 0.49
FL	19.12 ± 0.31	ND	10.90 ± 0.59	ND	ND	34.69 ± 2.72	10.95 ± 0.18
VS	10.24 ± 0.22	ND	9.12 ±0.50	ND	ND	BDL	48.13 ± 0.31