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Preliminary chemical evaluation of nutritional perspective of Pito, an indigenous alcoholic beverage brewed in the Upper East region of Ghana

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Abstract: *This study evaluated some macro and trace elements in a Ghanaian indigenous beverage, pito. Pito samples from the Upper East region, Ghana, were analysed using AAS, Spectrophotometry, and titration; for Ca, Mg, Na, K, Cu, Co, Cr, Fe, Al, Pb, As, Ni and Zn. 35.0 to 59.0 mg/L Ca; 16.97 to 30.74 mg/L Mg; 9.05 to 13.18 mg/L K; 18.03 to 26.15 mg/L Na; 0.11 to 0.18 mg/L Fe; 0.00 to 0.01mg/L Al, and 0.00 to 0.01 mg/L Cr were present. Also, 1.83 to 2.95 mg/L Zn; 0.05 to 0.07 mg/L Ni; 0.00 to 0.02 mg/L Cu, and 0.10 to 0.11 mg/L Co were found. Al and Cr were overall least (0.01 mg/L), while Pb and As could not be detected. Cr was only in one sample source, while generally Ni was above the WHO acceptable limit. Further analyses are required to enable comparison and recommendation of pito nutrient-supplement policy.*

Keywords: Pito, beverage, macro, trace elements, nutrient supplement

INTRODUCTION

Trace and macro elements have been reported in foods and local alcoholic beverages such as pito (Okoye and Ekpengyong, 1984; Obasi et al., 1987; Gazuwa et al., 2006). Foods are sources of all the nutrients required to accomplish the human physiological functions (Fraga, 2005; Willett, 2002), and contribute to health (Mokdad et al., 2004). However, human mineral deficiency is still a worldwide problem, especially in developing countries.

Intake of food and drinks are also major sources of heavy metals in non-occupationally exposed adults. This happens through ingestion, inhalation, breathing or absorption through the skin (International Occupational Safety and Health Information Centre, 1999). Humans may also become exposed to heavy metal toxins (Jarup, 2003) in industrial products (Correia et al., 2000). However, there is no good mechanism for heavy metals elimination from the human body (Suruchi and Pakanj, 2011). Heavy metals could therefore biomagnify and pose potential threat to human health (Sugiyama, 1994). Also, ingestion of, or exposure to, excess quantities of trace metals is often toxic (Bender et al., 2009).

Many different traditional alcoholic beverages are produced in West Africa from various types of agricultural produce (Sanni et al., 1999; Sefa-Dede et al. (1999). In Ghana, pito is a popular indigenous drink produced and consumed in northern parts of the country, and some settlements of Northerners in the southern sector (Sefa-Dedeh and Asante, 1988; Duodu et al., 2012). It is produced mainly from *Sorghum vulgare*, *Sorghum bicolor*, and/or millet (Sefa-Dede et al., 1999; Kolawole et al., 2007; Abagale et al., 2013). It has been reported that sugars are the principal fermentable carbohydrates in the beverage with ethanol as a major component of the product (Glover, 2007). The beverage is reported to contain lactic acid, sugars, amino acids, and an alcohol content of 2-3% (Ekundayo, 1969). Nutritional composition analyses had also indicated proximate content and presence of calcium, magnesium and iron in pito (Akinduyo et al., 2007; Kolawole et al., 2007). The beverage could therefore be a source of unconventional nutrient supplement to consumers, whilst it is still an indigenous beer. Assessment of macro and micro nutrients in samples of pito may therefore enable recommendation of the beverage.

In the current global high cost of living, people from developing countries should be encouraged to consume more of indigenous produce that are safe. Thus, assessment of nutritional quality of foods has become an important tool for the development of nutritional and health policies. The current research evaluated presence and levels of Zn, Fe, Na, K, Al, Co, Ca and Mg in duplicate samples collected from three popular pito centres in the Kasena-Nankana and Bolgatanga municipalities of the Upper East Region of Ghana. Arsenic, chromium, copper, lead, and nickel were also assessed.

MATERIALS

The samples used were pito brews collected from two major cities of Northern Ghana. Reagents used were of analytical grade and included; nitric acid, hydrochloric acid, distilled water, Erichrome Black “T” indicator, ammonia buffer solution, sodium hydroxide, ethylene diethylacetic acid, Murexide indicator and diphenylcarbohydrazide, HACH reagent powder pillows and standard solutions of Pb, Cu, Ni, Co and Zn.

Equipment and Glassware

Buck scientific, model 210 VGP Atomic Absorption Spectrometer (AAS), Hach DR/2000 spectrophotometer, electronic speed digester (R-450), pH meter**,** sampling bottles, ice chest, filter paper, funnel, conical flask, flat bottom volumetric flask, measuring cylinder and pipette.

Methods

Convenient non representative sampling was used to identify three popular pito brewing centres in the Kasena-Nankana and Bolgatanga municipalities of the Upper East Region of northern Ghana for sample collection.

Sample Collection

Six pito samples were collected; two each from three popular brewing centres in Navrongo and Sumbrungu near Bolgatanga. Samples were collected once a month for two successive months. The samples were collected, separately into acid cleaned high-density 1L polyethylene sampling bottles and transported on ice (Duodu et al., 2012), and stored prior to analyses.

Digestion of Samples

The samples were digested prior to analysis using an electronic speed digester, made in BUCHI-SWIZERLAND.

Laboratory Analyses

Before the analyses, the samples were acidified to pH < 2 using 10% analytical grade HNO_3. The samples were analysed according to strict protocols (Wardlaw, 1999; APHA, 1998). Replicate analyses were carried out to ensure reproducibility and good quality control.
Cu, Ni, Zn, Co and Pb were analysed using the AAS; Fe, Cr, K, Na, Al and Ca were analysed using the HACH DR/2000 spectrophotometer, or the Hatch One Laboratory pH/ISE meter, and by titration (Garcia et al., 2012).

RESULTS

Table 1 Mean Concentrations of chemical elements in Pito from Sumbrungu near Bolgatanga

Element	Mean (mg/L)	Interval (mg/L)	Deviation
Ca	35	32-40	3.317
Mg	16.97	15.5-19.5	1.521
K	9.4	8.2-10.6	1.020
Na	19.28	17.2-21.6	1.856
Fe	0.11	0.09-0.13	0.011
Al	0.01	0.00-0.01	0.000
Cr	0.01	0.00-0.01	0.000
Pb	-	0	-
Zn	1.8336	1.2438-2.1163	0.345

Cu	0.0189	0.0078-0.0273	0.006
Ni	0.0538	0.0432-0.0628	0.008
Co	0.1053	0.0927-0.0118	0.012
As	-	0	0

Table 2 Mean Concentration of chemical elements in Pito from UDS Navrongo campus

Element	Mean (mg/L)	Interval (mg/L)	Deviation
Ca	59.000	52.00-72.00	7.681
Mg	28.670	25.00-27.00	3.734
K	13.180	12.00-14.60	0.860
Na	26.150	24.80-28.20	1.438
Fe	0.190	0.15-0.24	0.032
Al	0.010	0	0.000
Cr	-	0	-
Pb	-	0	-
Zn	2.934	2.776-3.225	0.172
Cu	0.003	0.002-0.003	0.000
Ni	0.072	0.066-0.079	0.005
Co	0.099	0.074-0.123	0.019
As	-	0	-

Table 3 Mean Concentrations of elements in Pito from Navrongo Town Centre

Elements	Mean (mg/L)	Interval (mg/L)	Deviation
Ca	53	30.00-72.00	18.221
Mg	30.74	14.58-55.99	16.543
K	9.05	7.90-10.20	0.934
Na	18.03	15.20-19.70	1.196
Fe	0.18	0.09-0.03	0.062
Al	-	0	-
Cr	-	0	-
Pb	-	0	-
Zn	2.555	1.81-3.05	0.493
Cu	0.016	0.004-0.043	0.042
Ni	0.05	0.026-0.074	0.014
Co	0.16	0.112-0.215	0.044
As	-	0	-

The concentration of Fe in the samples ranged from 0.11 to 0.19 mg/L, the highest concentration being in the samples from UDS Navrongo campus (Table 2). Fe is an essential element in human diet and is found in natural fresh waters at levels ranging from 0.5 to 50 mg/L (Duodu et al., 2012). Estimates of the minimum daily requirement for Fe range from about 10 to 50 mg/day and depends on age, sex, physiological status and iron bioavailability and (Lenntech, 1998-2011). $Fe^{+2/+3}$ forms part of haemoglobin, which allows oxygen to be carried from the lungs to body tissues. Severe Fe deficiency causes anaemia in humans. The samples of pito analysed could therefore be a good source of supplementary Fe if consumed in Fe deficient communities.

The concentrations of Cu in the pito samples analysed were low compared to other elements (Ca, Mg, K, Na, Fe, Zn and Ni) in the samples. Mean concentrations of Cu determined were 0.0189 ± 0.01mg/L, 0.0028 ± 0.00mg/L and 0.0157 ± 0.04mg/L, in the samples as given in tables 1, 2, and 3 respectively. The highest and lowest concentrations of Cu were respectively found in samples from Sumbrungu (Table 1) and Navrongo Town Centre (Table 3). The highest detected concentration of Cu (0.0189mg/L) was less than the World Health Organisation (WHO) (2006) limit of 2 mg/L required in drinking water. Thus, pito may not be a very good source of Cu, an essential component of several enzymes and a necessity for the synthesis of haemoglobin (Kawasaki, 1974).

The presence of Cu and Zn in foods has both nutritional, and toxic effects in humans. Zinc forms an integral part of a number of metalloenzymes and as a catalyst for regulating the activity of over 300 specific zinc-depended enzymes (Conrad and Umbreit 2000). Also, both deficiency and excess of Cu may result in anemia. Gale and Robins (1989) suggested that diets low in Cu informs much of the epidemiology and patho-physiology of the tissue ion, the formation of the mitochondrial heme, and ischemic heart disease.

The highest concentration of Zn (2.93 mg/L) was found in samples from UDS Navrongo Campus in the Kasena-Nankana municipal (Table 2), whiles the lowest (1.83 mg/L) was in samples from Sumbrungu in the Bolgatanga municipal (Table 1). Though the guideline limits for drinking water indicated that the derivation of a guideline value for Zn is not required, drinking-water containing zinc at levels above 3 mg/L may not be acceptable for consumption (Lenntech, 1998-2011). Therefore, concentrations of Zn in the pito samples could be a supplementary for consumers. Zn is an essential trace metal for both animals and humans, deficiency of which is marked with retarded growth, loss of taste and hypogonadism, leading to decreased fertility (Anim et al., 2011). However, concentrations up to 40 mg/kg of Zn in water may induce toxicity, characterized by irritability, muscular stiffness and pain, loss of appetite, and nausea, though Zn toxicity is rare (NAS-NRC, 1975).

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Table 4 Mean Concentration of Elements in Pito Samples from the three Pito Centres

Sample Source	Mean Concentrations (mg/L) of:												
	Ca	**Mg**	**K**	**Na**	**Fe**	**Al**	**Cr**	**Pb**	**Zn**	**Cu**	**Ni**	**Co**	**As**
Sumb-rungu	35	17	9.4	19.28	0.11	0.01	0.01	0	1.83	0.02	0.05	0.11	0
UDS, Navrongo Campus	59	28.7	13.18	26.15	0.19	0.01	0	0	2.93	0	0.07	0.1	0
Navrongo Town Centre	53	30.7	9.05	18.03	0.18	0	0	0	2.55	0.02	0.05	0.16	0
WHO standard	-	-	-	-	0.2	0.2	0.05	0.01	3	2	0.02	0.2	0

Ni levels were generally very low in the pito samples relative to most other metals (Mg, Ca, Cu, Fe, Na, K, and Zn). However, in all of those samples that it was found, the concentration was far above the recommended limit of 0.02 mg/L (WHO, 2006) in drinking water. The levels in the current samples were from 0.05 to 0.07 mg/L. The highest concentration, (0.07 mg/L), was detected in the sample from UDS Navrongo Campus (Table 2). The major source of Ni for humans is food and up-take from natural sources (NAS-NRC, 1982). High levels of Ni in humans are not desirable, as increased incidence of cancer of the lung and nasal cavity are associated with high intake of Ni reported in workers of Ni smelters (Kawasaki, 1974).

Through the activity of natural phenomena such as earth quakes and rock weathering, trace and mineral metals may be released into the soil and water bodies. These can then be absorbed by plants and thus increase the trace and mineral metal levels in the plants. Consequently, when these plants, and water are used as raw materials in pito brewing, the minerals will definitely get into the beverage. Also, fermentation of pito is usually done using clay or metallic (alloys, iron, aluminium or galvanised) containers as fermentation vessels. Therefore, it is possible for trace elements such as Zn, Cu, Fe among others to be brought into the beverage through corrosion of the vessels, and the water used in brewing (Okoye, 1990; Gazuwa et al., 2006).
From table 4, mean calcium content was the highest in all the pito samples. The least mean K concentration was 9.40±1.02 mg/L, and the highest was 13.18±0.86 mg/L. Also, the highest mean concentration of Na was 26.15±1.44 mg/L in samples from UDS Navrongo Campus (Table 4). Sodium helps to regulate blood pressure, fluid balance, transport of carbon dioxide, and also affects cell membrane permeability, and other cell membrane functions. Its deficiency causes fatigue and fluid imbalances such as low blood pressure. Potassium is also essential for regulation of heartbeat, fluid balance and maintenance of blood pressure. It is needed for buffering the blood, and has cell membrane effects including nerve transmission and muscular contraction. Potassium and sodium are osmoregulatory macro-minerals required for the maintenance of cellular water balance, acid-base balance and nerve transmission, and are required in large amounts in the body. Deficiencies of these macronutrients lead to muscle

cramps, mental confusion, fatigue, loss of appetite and irregular cardiac rhythm (Wilson, 2012). Sodium intake and hypertension in humans are directly related (WHO, 2006).

Mean levels of Al, Cr, Pb, and As in the samples were each below the standard WHO level for drinking water. Pb, a toxic metal, was below detection limit in all the samples, and Cr, also a potentially toxic element, was below the threshold limit and also detected (0.01mg/L) only in one sample. As was also below detection limits. High levels of Pb in foods either in acute or chronic exposure may result in food poisoning in humans. A study by Baht (1997) indicated that accumulation of lead produces damaging effects in the hematopoetical, hematic, renal, and gastrointestinal systems. Toxic trace metals such as these could have been introduced into the beverage by exogenous factors during processing and production of the beverage. Absence of Pb in the samples is very valuable since this makes the samples safe from lead poisoning.

Interestingly, Ca, Mg, Na, K, and Fe which are all essential elements were of relatively high concentrations in all the samples. Consumption of pito could therefore be a good supplementary source of these trace elements and minerals. Calcium is required for the regulation of cell membrane permeability to control nerve impulse transmission and muscle contraction. It is incorporated mainly in bones, and is also important for blood clotting, and regulation of hormonal secretion and cell division. Magnesium is required for over 500 enzymes that regulate sugar metabolism, energy production, cell membrane permeability, as well as muscle and nerve conduction. Mg deficiency also causes muscle cramps, weakness, depression and fatigue. It also works closely with potassium, and is a calcium antagonist (Wilson, 2012).

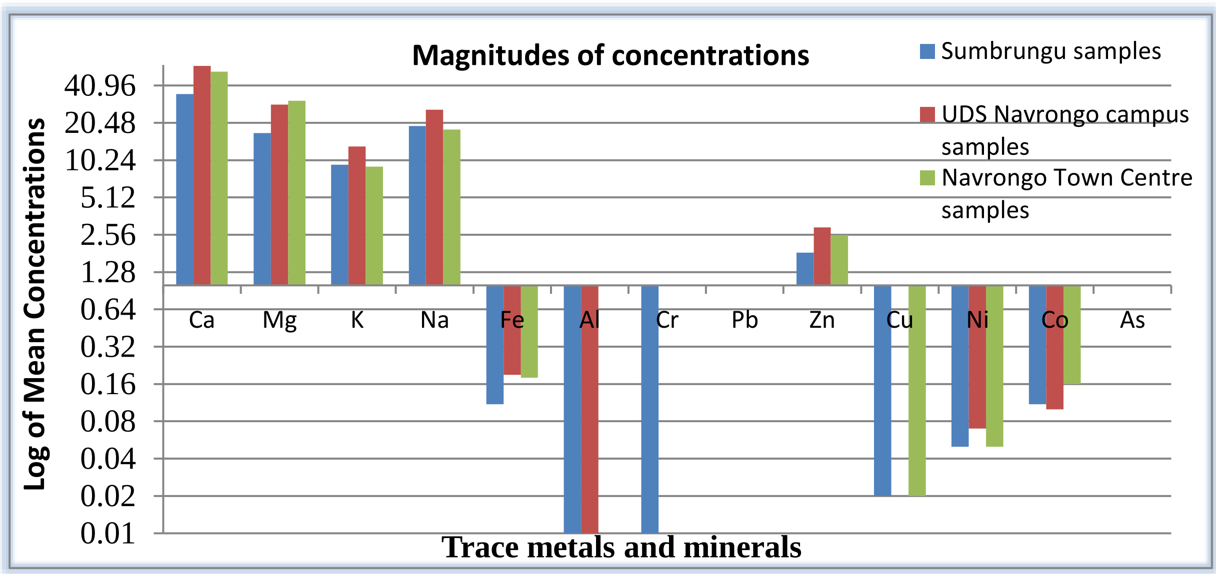

Figure 1 Magnitudes of Trace Metals and Minerals in the Pito Samples

Out of thirteen trace and heavy metals analysed, concentrations of five metals (Ca, Mg, K, Na, Zn) were above 1.0 mg/L, while the rest were below (Figure 1). It is desirable that the concentration of sodium in foods is not as high as that of potassium. The current results however indicated higher concentration of Na than K which implies the consumption of pito from these sources might not maintain the required balanced proportions. In the indigenous pito brewing process chemical standardization is usually not enforced. Comparatively, mineral profile of pito investigated earlier by Duodu et al. (2012) indicated a general trend of trace metals concentration as K>Na>Zn>Fe>Mn>Pb>Ni>Cu>Cd>>Cr.

Pito samples in the current study could relatively serve as supplementary sources of nutrients including Ca, Mg, Cu, Zn, Fe, Na, K Cr, Co and Ni to consumers. These are essential components of nutrition to consumers of the product. However, this will largely be possible only if pito brewing is standardized with quality control measures optimized.

CONCLUSION

Analyses of the pito samples showed that the samples contain more of the mineral elements than the trace metals. The respective mean concentrations were in the range of 35 to 59 mg/L Ca, 16.97 to 30.74 mg/L Mg, 9.05 to 13.18 mg/L K, 18.03 to 26.15 mg/L Na, 0.11 to 0.18 mg/L Fe, 0.00 to 0.01 Al, 0.00 to 0.01 mg/L Cr; 0.00 mg/L Pb and also As; 1.83 to 2.95 mg/L Zn, 0.05 to 0.07 mg/L Ni, 0.00 to 0.02 mg/L Cu and then 0.10 to 0.11 mg/L Co in samples collected in replicates from the three centres. All the samples contained all the trace metals and minerals analysed. The trace metals and minerals analysed were largely present at levels within recommended limits of the WHO in drinking water.

Ca was in highest concentration (35, 53, 59 mg/L in the three centres) relative to the others analysed. As and Pb could not be detected in the samples. Though they could accumulate, all the metals determined with the exception of Ni, were at levels below the WHO maximum limits in drinking water. Representative analyses of pito samples are required to establish consistent content-data of the beverage to enable standardization and recommendation for commercialization as a food supplement. Also, analysis of samples at pre-fermentation stages of pito production should be done in order to provide valuable inference information.

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