

Mineral Profile of Pito from Accra, Tamale, Bolgatanga and Wa in Ghana

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Abstract This study was undertaken to investigate the mineral profile of pito, a traditionally brewed alcoholic beverage popularly consumed along West Coast of Africa. Pito samples from four cities in Ghana namely; Bolgatanga, Tamale, Wa and Accra were analysed for their metal content. Concentrations of Na, K, Mn, Cu and Zn, were measured in all the samples analysed. However, Fe, Ni, Cd and Pb recorded 70%, 83%, 58% and 79% incidence respectively in the samples, but Cr was measured below detection limit in all the samples. The concentrations of Na, K, Mn, Cu, Zn, Fe, Ni, Pb and Cd recorded ranged between 15 to 66mg/L, 581 to 1108mg/L, 0.152 to 0.808mg/L, 0.076 to 0.308mg/L, 0.456 to 0.910mg/L, 0.308 to 2.832mg/L, 0.040 to 0.176mg/L, 0.056 to 0.272mg/L and 0.011 to 0.048mg/L respectively. With the exception of Mn, all the essential minerals measured were below the recommended WHO maximum limits in water. Hence pito is a good source of K, Na, Fe, Cu and Zn. The detected concentrations of Ni, Pb and Cd in the pito samples were however, above the respective maximum WHO guideline in water. Therefore pito is susceptible to metal contamination due to poor handling and primitive equipment used in the production and consumers should be apprehensive of the environs where the pito is prepared.

Keywords Pito, Mineral, Concentration, Guideline, Maximum Limit, Recorded

1. Introduction

Pito is a local traditionally brewed alcoholic beverage in some parts of West Africa including Ghana. It is produced mainly from the grains of guinea corn (*Sorghum vulgare* and *Sorghum bicolor*)[1] and/or millet. Sorghum is one of the most important crops in Africa, Asia and Latin America[2,3]. More than 35% of sorghum is grown directly for human consumption. The rest is used primarily for animal feed, alcohol production and industrial products[3,4,5,].

Pito is golden yellow to dark brown in colour with taste varying from slightly sweet to very sour and contains sugars, lactic acid, amino acids, 2-3% alcohol, proteins and vitamins[6]. As described by[7], the process of production of burukutu involves washing of the grains, steeping, mashing, wort extraction, fermentation and maturation. The microorganisms associated with fermentation include *Saccharomyces cerevisiae*, *Saccharomyces chavelieria* and *Leuconostoc mesteroides*. The process of pito production is similar to burukutu production except that, in pito produc-

tion, the pH increases from about 4.2 to 6.2 within 24h of fermentation and it decreases further to 3.7 after 48h if different types of grains are used to brew it and no adjunct is added[8]. *Geotrichum candidum* and *Lactobacillus species* have been described to be responsible for souring pito[1].

Due to differences in wort extraction and fermentation processes, 4 types of pito namely, Nandom, Dargati, Togo and Kokomba are consumed in Ghana. Their peculiar differences and characteristics are described by Sefa-Dedeh et al, 1999. Pito is popularly consumed in the three northern regions and the Zongo communities (settlements of the northerners in the southern sector of Ghana) of Ghana, parts of Nigeria, and other parts of West Africa[9]. Due to the simplicity of production, availability of raw plant materials and abject poverty in these communities, pito brewing can provide an important source of income for otherwise cash-poor households in rural areas. In Ghana, Pito is not found bottled or canned, and, as a rule, is purchased directly from the household in which it is brewed. It is typically served in a calabash outside the producer's home where benches are sometimes provided.

Studies by Kolawole et al. 2007, looking at the nutritional composition and microbial analysis of pito found out that they contained mineral elements such as calcium, magnesium and iron that were essential for regulating and building

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Published online at <http://journal.sapub.org/fph>

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the living cells and aid in fighting depression. Microorganisms such as *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Streptococcus* species, *Proteus* species, *Rhizopus stolonifer*, *Aspergillus flavus*, *Aspergillus niger*, *Saccharomyces cerevisiae* and *Mucor* species were also isolated from the samples. They explained that the presence of some these microorganisms in the samples may be attributed to poor handling during production. Some strains of *E. coli* can cause gastroenteritis and urinary tract infection as well as diarrhea in infant.

Due to the crude nature of production and poor handling during and after preparation, the elemental profile was carried out to ascertain the introduction of some metals into pito. Assessment of nutritional quality and safety of food consumed by the public is an important tool for the development of nutritional and health policies in a nation[10].

Humans are exposed to metals by ingestion through drinking or eating, by inhalation through breathing or by absorption through the skin when they come in contact with humans during our daily activities in agricultural, pharmaceutical, industrial or residential settings among others[11]. According to World Health Organization (WHO, 1995), research estimates from various countries indicate that the major sources of heavy metals for non-occupationally exposed adults are from food and drink. Also industrial activities and products that expose humans to heavy metal toxins include the manufacturing of pesticides, batteries, alloys, electroplated metal parts, textile dyes, steel among others[12].

Heavy metals such as lead (Pb), mercury (Hg), cadmium (Cd) and arsenic (As) are generally regarded as environmental contaminants and their presence in foods or drinks can have some toxic effects on human. High levels of Pb in foods may result to food poisoning in humans either in acute or chronic exposure. Accumulation of lead produces damaging effects in the hematopoietical, hematic, renal, gastrointestinal systems[13,14]. Zinc plays a role as an integral part of a number of metalloenzymes and as a catalyst for regulating the activity of over 300 specific zinc-dependent enzymes[15]. The role that copper plays in anemia is related to the mobilization of the tissue iron, the formation of the mitochondrial heme, and the reduction of erythrocyte half-life[16]. Both copper deficiency and excess result in anemia[17]. Copper has no pro-oxidant activity at a considerably higher intake[18]. Diets low in copper are suggested as an explanation for much of the epidemiology and patho-physiology of ischemic heart disease[19]. However, the presence of Cu and Zn in foods has both nutritional and toxic effects in humans.

2. Sampling and Analysis

Pito samples were bought from four different cities Tamale, Wa, Bolgatanga and Accra between February and March 2011. Six (6) samples each were taken from all the cities except Accra where only 3 were taken. The three ci-

ties Bolgatanga, Tamale and Wa were chosen due to the unique method of preparation and popularity of consuming pito. The 3 sampling sites in Accra reflect the preparation method in the 3 cities above. All 21 samples were collected, put separately into acid cleaned high-density 1L polyethylene sampling bottles and analyzed according to strict sampling protocols described by[20]. The samples were transported in ice cooler on ice and stored at -4°C , prior to analysis. Chemical analyses on the samples were conducted using standard procedures recommended by[21]. Analysis of Na^{+} and K^{+} ion concentrations were done using a Sherwood model 420 flame photometer. Samples for trace metal analysis were acidified to $\text{pH} < 2$ with 10% analytical grade HNO_3 . They were then acid digested using an ETHOS 500 model microwave and read using Varian AA240FS model Atomic Absorption Spectrophotometer in an air-acetylene flame at the Nuclear Chemistry and Environmental Research Centre, Ghana Atomic Energy Commission. Analytical grade reagents were used for all analysis and replicate measurements were done to ensure reproducibility and good quality control.

Positive Control: Single element e.g. Cd, Cu, Pb, and Fe reference standard samples (Spectrascan, Sweden) standard reference material included in the analysis were treated as a sample as described above. These served as internal positive control sample.

3. Results and Discussions

From figure 1, potassium measured the highest concentration in all the pito samples. The general trend of the trace metals concentration were in the order; $\text{K} > \text{Na} > \text{Zn} > \text{Fe} > \text{Mn} > \text{Pb} > \text{Ni} > \text{Cu} > \text{Cd} > \text{Cr}$. Relatively, Pb which is a toxic trace metal measured almost the same concentrations in the samples from Tamale, Wa and Accra with Bolgatanga recording a lower concentration. Cr which is also a potentially toxic element in the Cr^{3+} state had concentrations below detection limits in all the samples. These toxic trace metals may have been introduced during handling and production of the pito. Interestingly, Na, K, Fe, Zn, Mn, Cu and Ni which are all essential elements measured relatively higher concentrations, thus indicating that consumption of pito could be a good source of supplement of these trace metals.

The mean concentrations of K are 750.50 ± 90.25 , 942.67 ± 176.97 , 694.75 ± 117.50 and $790.00 \pm 9.19 \text{mg/L}$ whilst those of Na are 21.75 ± 12.20 , 28.33 ± 9.71 , 60.25 ± 4.19 and $25.50 \pm 3.54 \text{mg/L}$ recorded at Bolgatanga, Tamale, Wa and Accra respectively. The lowest K concentration measured was 581mg/L (Table 3) and the highest being 1108mg/L (Table 2) recorded at Wa and Tamale respectively. The lowest Na concentration was 15mg/L (Table 1) with the highest being 66mg/L (Table 3) also recorded at Bolgatanga and Wa respectively (Table 1 and 3). Potassium and sodium are 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[22,23]. Deficiencies of these macronutrients lead to muscle cramps, mental confusion, loss of appetite and irregular cardiac rhythm[23]. However, there is a direct relationship between sodium intake and hypertension in humans[24]. Therefore it is desirable that the concentration of sodium in foods is not as high as that of potassium. These results therefore indicate a desirability of the consumption of pito because they contain high concentrations of sodium and potassium but the concentration of sodium is lower than that of potassium.

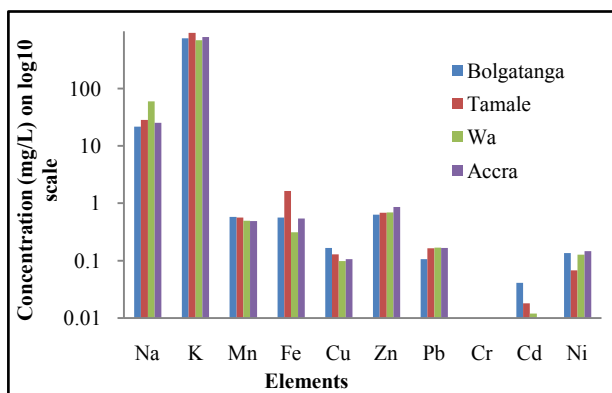


Figure 1. trace element concentrations in the pito samples from the various cities

Table 1. Concentration of elements (mg/L or ppm) in pito samples from Bolgatanga

Element (mg/L)	n	Mean	Interval	STD DEV
Na	6	21.75	15 - 40	12.203
K	6	750.5	629 - 824	90.253
Mn	6	0.583	0.420 - 0.792	0.19
Fe	3	0.568	0.501 - 0.660	0.33
Cu	6	0.166	0.112 - 0.308	0.095
Zn	6	0.636	0.456 - 0.868	0.173
Pb	5	0.106	0.088 - 0.124	0.018
Cr	0	<0.001		
Cd	6	0.041	0.032 - 0.048	0.007
Ni	5	0.135	0.108 - 0.172	0.034

n = Total number of samples analysed in this city (6). However values lower than this under this column means that in such instance the element concentration in those samples are below the detection limit for the analytical technique applied. Hence, these values were not used in the statistical analysis.

Table 2. Concentration of elements (mg/L or ppm) in pito samples from Tamale

Element (mg/L)	n	Mean	Interval	STD DEV
Na	6	28.333	20 - 39	9.713
K	6	942.667	756 - 1108	176.967
Mn	6	0.563	0.152 - 0.808	0.358
Fe	5	1.648	0.464 - 2.832	1.674
Cu	6	0.129	0.096 - 0.176	0.042
Zn	6	0.683	0.580 - 0.776	0.098
Pb	5	0.164	0.056 - 0.272	0.153
Cr	0	<0.001		
Cd	5	0.018	0.012 - 0.024	0.008
Ni	5	0.068	0.040 - 0.096	0.040

The mean concentrations of Mn were 0.583 ± 0.19 , 0.563 ± 0.358 , 0.498 ± 0.158 and 0.488 ± 0.065 mg/L recorded at Bolgatanga, Tamale, Wa and Accra respectively. The highest concentration of 0.808 mg/L (Table 1) exceeds the

WHO (2006) guideline of 0.4 mg/L[25] while the lowest, 0.158 mg/L (Table 1) also exceeded the EU (1998) guideline of 0.05 mg/L[26] in drinking water. Mn is an essential element for animals. Deficiencies of Mn result in severe skeletal and reproductive abnormalities in mammals. It is widely distributed throughout the body with little variation and does not accumulate with age[27].

Table 3. Concentration of elements (mg/L or ppm) in pito samples from Wa

Element (mg/L)	n	Mean	Interval	STD DEV
Na	6	60.250	56 - 66	4.193
K	6	694.750	581 - 856	117.503
Mn	6	0.498	0.320 - 0.696	0.158
Fe	3	0.312	0.308 - 0.315	0.180
Cu	6	0.099	0.076 - 0.116	0.020
Zn	6	0.694	0.572 - 0.820	0.124
Pb	3	0.168	0.096 - 0.240	0.102
Cr	0	<0.001		
Cd	3	0.012	0.011 - 0.012	0.001
Ni	4	0.127	0.044 - 0.176	0.072

The concentration of Fe ranged between 0.308 to 2.832 mg/L. The highest concentration was recorded at Tamale (Table 2) with the lowest recorded at Wa (Table 3). 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. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status and iron bioavailability and range from about 10 to 50 mg/day[25]. It forms part of haemoglobin, which allows oxygen to be carried from the lungs to the tissues. Severe Fe deficiency causes anaemia in humans.

The concentrations of Cu in the pito samples analysed were low compared to other essential minerals. Cu concentrations ranged from 0.076 to 0.308 mg/L, with the highest and lowest concentrations measured at Bolgatanga (Table 1) and Wa (Table 3) respectively. Moreover, the highest concentration of 0.308 mg/L measured was below WHO (2006) guideline of 2 mg/L in drinking water (Table 5). Hence pito will not be a good source of Cu. Cu is an essential part of several enzymes and it is necessary for the synthesis of haemoglobin[28].

The lowest concentration of Zn 0.456 mg/L was measured at Bolgatanga (Table 1) while the highest concentration 0.910 mg/L was measured at Accra (Table 4). Though the WHO 1993 Guidelines for drinking water concluded that the derivation of a guideline value is not required, drinking-water containing zinc at levels above 3 mg/L may not be acceptable to consumers[25]. Therefore, the concentrations of Zn in the pito samples are acceptable for consumers. Zn is an essential trace metal for both animals and humans. A deficiency of zinc is marked by retarded growth, loss of taste and hypogonadism, leading to decreased fertility[27]. Zn toxicity is rare but, at concentrations in water up to 40 mg/kg, may induce toxicity, characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea[29].

Ni recorded very low concentrations in the pito samples

relative to the other heavy metals apart from Cd which recorded the lowest concentration relatively. The concentrations of Ni in the samples ranged between <0.01 to 0.176mg/L. The highest concentration, 0.176mg/L was measured at Wa (Table 3) with the lowest detectable concentration, 0.040mg/L recorded at Tamale (Table 2). The concentration of Ni in 2 samples from Wa (Table 3) and a sample each from Bolgatanga and Tamale (Table 1 and 2) were below the detection limit of 0.01mg/L of the analytical method used. The WHO (2006) guideline for Ni in drinking water is 0.02mg/L (Table 5). Thus the concentrations of Ni detected in all the samples were far above the stipulated limit. The major source of Ni for humans is food and uptake from natural sources, as well as food processing[30]. Increased incidence of cancer of the lung and nasal cavity caused by high intake of Ni has been also been reported in workers of Ni smelters[28].

Table 4. Concentration of elements (mg/L or ppm) in pito samples from Accra

Element (mg/L)	n	Mean	Interval	STD DEV
Na	3	25.500	22 -29	3.536
K	3	790.500	782 - 797	9.192
Mn	3	0.488	0.449 - 0.546	0.065
Fe	3	0.544	0.527 - 0.560	0.023
Cu	3	0.107	0.096 - 0.117	0.013
Zn	3	0.859	0.815 - 0.910	0.058
Pb	3	0.166	0.111 - 0.223	0.076
Cr	0	<0.001		
Cd	0	<0.002		
Ni	3	0.146	0.125 - 0.168	0.031

Table 5. A comparison of metal concentration range (mg/L) in all samples with WHO maximum limit in drinking water

Element	Detected concentration range (mg/L)	Maximum limit WHO (2006)
Na	15 - 66	NA
K	581 - 1108	NA
Mn	0.152 - 0.808	0.4
Fe	0.308 - 2.832	NA
Cu	0.076 - 0.308	2
Zn	0.456 - 0.910	3
Pb	0.056 - 0.272	0.01
Cr	<0.001	NA
Cd	0.011 - 0.048	0.003
Ni	0.040 - 0.176	0.02

NA= Not available

The presence Pb in foods can have some toxic effects in human. Pb concentrations ranged from <0.01 to 0.272mg/L, with the highest and lowest detectable concentrations of 0.272mg/L and 0.056mg/L respectively recorded at Tamale (Table 2). However, Pb was not detected in 3 samples from Wa (Table 3) and a sample each from Bolgatanga and Tamale (Table 1 and 2). All the concentrations of Pb detected in the pito samples were far above the WHO (2006) guideline of 0.01mg/L (Table 5) in drinking water. Pb is a cumulative poison and long-term exposure may cause kidney damage, anemia, nerve and brain damage, and even death.

Cd is classified as one of the most toxic heavy metals. The lowest detectable concentration of Cd, 0.011mg/L was measured at Wa (Table 3) while the highest concentration,

0.048mg/L was measured at Bolgatanga (Table 1). Cd was not detected in all pito samples from Accra (Table 4), 3 samples from Wa (Table 3) and a sample from Tamale (Table 2). The detected concentrations of Cd in all the pito samples, however, were far above the WHO (2006) guideline of 0.003mg/L (Table 5) in drinking water. Food is the main source of daily exposure to cadmium. Severe toxic symptoms resulting from Cd ingestion are reported between 10 to 326mg[27]. Fatal ingestions of Cd, producing shock and acute renal failure, occur from ingestions exceeding 350mg[31].

4. Conclusions

The mineral profile of pito samples indicates the presence of both essential and toxic metals. With the exception of Mn, all the essential minerals measured were below the recommended maximum limits. Hence pito is a good source of K, Na, Fe, Cu and Zn. The detected concentrations of Ni, Pb and Cd in the pito samples were above the respective maximum guideline. However, not all the pito samples analysed were these metals found. Therefore the introduction of these toxic metals in pito could be attributed to poor handling during preparation or the utensils used for the production and not from the raw materials (grains) used. Further studies need to be done on the brewing utensils and the possible reactions that can occur between pito and the utensils. But more importantly, consumers should be apprehensive of the environs where the pito is prepared. The results can be used to evaluate the possible health risk associated with the consumption of pito.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the Nuclear Chemistry and Environmental Research Centre, National Nuclear Research Institute, Ghana Atomic Energy Commission for making available the equipment and materials for the analysis. We express our profound gratitude to Miss Lebene Kpatah, Mr. Nash .O. Bentil and Mr. Michael Tawiah for assisting in the laboratory analysis of the samples.

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