Original Research Article

EFFECT OF TEA AND COFFEE CONSUMPTION ON BLOOD LEVELS OF SOME HEAVY METALS AND TRACE METALS

ABSTRACT

The human body requires both metallic and non-metallic elements for healthy growth, development and the proper functioning of the body. The determination of these elements in beverages, water, food, plant and soil is, thus, of utmost importance and is currently the subject of studies by ±various researchers. In the present study, the content of Cd, Pb, Hg, Zn, Cu, and Se in blood following extended consumption of tea and coffee has been determined. By random sampling method, sixty participants were selected for this study and grouped into 20 tea consumers, 20 coffee consumers and 20 controls. They were administered tea and coffee beverages respectively daily for 30 days, after which venous blood samples were collected from each participant into lithium heparin container. Blood Pb, Cd, Hg, Cu, Zn and Se were determined by employing Flame Atomic Absorption Spectrophotometry. All data generated were used to perform statistical analysis employing SPSS version 21. Blood Cd, Pb, Hg and Se were significantly higher (p=0.005, p=0.003, p=0.001 and p=0.048, respectively) in tea Consumers compared with controls, while there were no significant difference in blood levels of Cu and Zn (p=0.923 and p= 0.784 respectively) in tea Consumers compared with controls. Blood Cd, Pb, Hg, Zn and Se were significantly higher (p=0.001, p=0.000, p=0.012, p=0.037 and p=0.006 respectively) in Coffee Consumers compared with Controls. There werewas no significant difference in blood Cu (p=0.222) in Coffee Consumers compared with Controls. There were no significant differences in blood levels of Cd, Pb, Hg, Cu, Zn and Se (p=0.154, p=0.459, p=0.662, p=0.226, p=0.080 and p=0.705 respectively) in Tea Consumers compared with Coffee Consumers. There were significant negative correlations of blood Pb with Hg and Cu(r=-0.451, p=0.046 and r=-0.697, p=0.001 respectively) in Tea Consumers. There were significant negative correlations of blood Pb with blood Cu and Zn (r=-0.656, p=0.002 and r=-0.690, p=0.001 respectively) and significant positive correlation of Pb with Hg (r=0.538, p=0.017) in Coffee Consumers. It seemsThese findings have shown that Tea and Coffee Consumption may be associated with higher blood levels of Pb, Cd, Hg and Se;, hencethus, caution should be applied considering the deleterious effects of heavy metals.

Keywords: Tea, Coffee, Heavy Metals, Trace Elements, Blood

1.0 INTRODUCTION

Tea is one of the most consumed beverages in the world and is prepared from the leaves of the shrub, *Camellia sinensis* [1]. Green and black teas are the two most popular types. Drying and roasting the leaves produces green tea; black tea is obtained after a fermentation process. Tea, when prepared by infusion of leaves, flowers, or roots, has generated significant scientific interest due to its increased consumption, antioxidant activity, and presence of some micronutrients, such as minerals, flavonoids, and catechins [2]. Studies have shown a presence of potentially toxic and cumulative substances in herbs such as inorganic contaminants [3]. These contaminants originate from different aspects of the herbal tea manufacturing process and include sources such as soil and water, fertilizers, and airborne industrial emissions [4].

Tea leaves (*Camellia sinensis*) are source of such mineral elements as essential for health: zinc, manganese, iron, magnesium, copper, titanium, aluminum, bromine, sodium, potassium as well as nickel, chromium and also phosphorus [5]. Several attempts have been made to assess tea quality by chemical analysis usually with reference to pigmentation and the flavouring characteristics. Metallic constituents of tea leave is normally different according to the type of tea (green or black) and geological sources [6]. However, to date little work has been done to identify the metal containing components of tea due to the analytical difficulties associated with both the separation of such components and their quantitative measurement [1].

Coffee is a brewed drink prepared from roasted coffee beans, which are the seeds of berries from the coffea plant. The genus *Coffea* is native to tropical Africa (specifically having its origin in Ethiopia and Sudan) and Madagascar, the Comoros, Mauritus and Reunion in the Indian Ocean [7]. The primary psychoactive chemical in coffee is caffeine [8]. Coffee is the second most

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popular drink after water in the world. Coffee consumption varies widely according to geographical location. The highest consumption has been observed in Northern Europe (Finland; 12.0 kg per capita/year) whereas in Southern Europe the highest consumption is in Bosnia and Herzegovina (6.1 kg per capita/year). According to the International Coffee Organization, in 2008 coffee was consumed at a rate of 2.5 billion cups per day (1 cup = 30 mL). This consumption is a model for addictive behavior.

Genetic investigations in twins suggest that the heritability of coffee intake can be estimated to be in the range of 39 to 56% [9, 10]. Coffee seems to have distinct acute and long-term effects on health. Interestingly, its consumption has been suggested to be beneficial in dementia, Alzheimer's disease, Parkinson's disease and diabetes mellitus type 2 [11, 12]. However, other researchers have associated coffee drinking with an increased risk of developing coronary heart disease [13].

Many elements present in food at major, minor and trace levels are reported to be essential to man`s wellbeing. However, their ingestion in excessive amount can cause severe health problems [14]. Human body requires both metallic and non-metallic elements for healthy growth, development and the proper functioning of the body. The determination of these elements in beverages, water, food, plant and soil is thus of utmost importance and is currently the subject of studies by ±various researchers [1]. In the present study, the content of Cd, Pb, Hg, Zn, Cu, and Se in blood following extended consumption of tea and coffee has been determined.

Tea, when prepared by infusion of leaves, flowers, or roots, has generated significant scientific interest due to its increased consumption, antioxidant activity, and presence of some micronutrients, such as minerals, flavonoids, and catechins [2]. Studies have shown a presence of

potentially toxic and cumulative substances in herbs such as inorganic contaminants [3]. These contaminants originate from different aspects of the herbal tea manufacturing process and include sources such as soil and water, fertilizers, and airborne industrial emissions [4]. Depending on the concentration, potentially toxic elements can cause damage to human health ranging from liver and kidney dysfunctions to carcinogenesis. However, not all contaminants remain in the tea infusion. Most residual toxins are present in very low levels, lowering the risk associated with tea ingestion. The health hazards associated with heavy metals such as lead, mercury and cadmium as well as toxicity of elevated levels of trace metals is well known. The scanty literature that exist as regards the effects of tea and coffee consumption on blood heavy metal and trace metal levels necessitate the study of the influence of these popular beverages in affecting heavy metal and trace metal levels in blood.

2.0. MATERIALS AND METHODS

Pre-survey Contact

Before commencement, the informed consent of the participants was obtained before enrollment into the study. They were assured of confidentiality of the information obtained from them during and after the study. Using Random Sampling method, a total of 60 randomly selected individuals were allocated into four groups in a transversal analytic study: Study Group 1(SG1) - 20 individuals aged 20-30 years who participate in coffee consumption regularly; Study Group 2(SG2) - 20 individuals who partake in regular consumption of tea; Control Group (CG) – 20 controls chosen from the general population, aged 17-30 years, who did not partake in tea or coffee consumption. The Groups 1 and 2 were given a cup of tea made of 1 Lipton yellow label

tea bag, and 1 sachet of Nescafe coffee sachet, respectively daily for 40 days. They were monitored to ensure that they took it at sight. Additional demographic data were obtained using the study questionnaires during a structural interview. It included basic socioeconomic information, some medical health history, occupational and other exposure to heavy metals. Every participant signed an informative form thereby indicating their consent.

Sample Collection

Blood Samples were collected using tourniquet, 5ml syringe, cotton wool, 70% alcohol, and labeling tapes, from the participants and dispensed into lithium heparin tubes using 5ml syringe.

Methods of Analysis of Serum Heavy Metals and Trace metals

The individuals were referred for venous blood sampling to assess the levels of Pb, Hg, Cd, Zn, Cu and Se. Plasma concentrations of Pb, Hg, Cd, Zn, Cu and Se were determined by Atomic Absorption Spectrophotometry (AAS). Reference values were those recommended by Springboard diagnostics, Awka. Heavy metal analysis was conducted using Varian AA240 Atomic Absorption Spectrophometer according to the method of APHA (American Public Health Association) [15]. Atomic spectrophotometry is designed to determine the amount of an object element in a sample utilizing the phenomenon that the atoms in the ground state absorb the light of characteristic wavelength passing through an atomic vapor layer of the element. Normally the apparatus consists of a light source, a sample-atomizer, spectroscope, and a photometer, including a reading system. Some are equipped with a background compensation system. A hallow cathode lamp and a discharge lamp are mainly used for the light source. The sample atomizer is composed of a burner and a gas flow regulator and also the spectroscope, and

a grating for double-deionized water. The specific light source lamp to the lamp housing was fixed, and the instrument was switched on. The source lamp was lighted and the wave length dial of the spectroscope was adjusted to the wavelength of the analytical line specified and set at an appropriate current value and slit-width. Using the supporting gas and the combustible gas specified, the mixture of gases was ignited and the gas flow rate and pressure was adjusted, then the zero adjustment was made after neutralizing the solvent into the flame. Using wavelengths of 228.8nm, 217.3nm, 253nm, 213.9nm, 324.8nm and for cadmium, lead, mercury, zinc, copper and selenium respectively the metals were analyzed and the instrument calibrated before use.

Digestion and analysis of samples for lead, mercury, cadmium, zinc, selenium and copper

Fresh whole blood collected in special lead-free tube containing lithium heparin was used for blood lead, mercury, cadmium, zinc, selenium and copper assay. 1 mL of nitric acid was added to 1 mL of sample and mixed properly. The mixture was boiled at 100 ^{o0}C for 30mins. Distilled water was added to make up to 10 mL for analysis. The contents were mixed and filtered using filter paper to get a clear solution. Then the mixture was transferred for analysis. Blood samples were analyzed using FS240AA agilent atomic absorption spectroscopy [16].

Working principle of Flame Atomic Absorption Spectrophotometry (AAS)

Atomic absorption spectrometer's working principle is based on the sample being aspirated into the flame and atomized when the AAS's light beam is directed through the flame into the monochromator, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element is used, making the method relatively free

from spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

Preparation of reference solutions

A series of standard metal solutions in the optimum concentration range are prepared, the reference solutions were prepared daily by diluting the single stock element solutions with water containing 1.5 mL~~l~~ concentrated nitric acid/litre. A calibration blank was prepared using all the reagents except for the metal stock solutions. Calibration curve for each metal was prepared by plotting the absorbance of standards versus their concentrations.

Calculation

The concentration for blood heavy metals were calculated using the following formulas;

$$\frac{\text{Reading of sample}}{\text{Reading of standard}} \times \text{Concentration of standards} = \text{R}$$

R × Final volume after digestion of sample = concentration of sample (µg/dl)

Conversion factor

ng/dl ÷ 10 = µg/dl

g/lv× 100 = µg/l

Anthropometry

Body Mass Index (BMI): The BMI was calculated as follows: weight (kg)/[height × height (m^2)].

Height (cm): Standing height in cm was measured taking the maximum distance from the floor to the heighest point on the head, when the subject was facing forward. Shoes were put off, feet together and arms by the sides. Heels, buttocks and upper back were in contact with the wall when the measurement was made.

Weight (kg): Weight was assessed using a bathroom scale when the subject was standing on its face forward. Shoes were put off, feet together and arms by the sides when the measurement was made.

Statistical Analysis

All data generated from this study were subjected to statistical analysis. Mean, standard deviation, student's t-test, and correlations were analyzed using SPSS. Results were expressed as Mean ± SD. The 5% (0.05) level of significance was adopted for significance.

RESULTS

Blood Heavy Metals and Trace Metals in Tea Consumers versus Controls

Blood Cd, Pb, Hg and Se were significantly higher (p=0.005, p=0.003, p=0.001 and p=0.048 respectively) in tea Consumers compared with controls. There were no significant difference in blood levels of Cu and Zn (p=0.923 and p=0.784 respectively) in tea Consumers compared with controls (Table 1).

Table 1: Blood Heavy Metals and Trace Metals in Tea Consumers versus Controls

VARIABLES (MEAN±SD)	TEA CONSUMERS (n=20)	CONTROLS (n=20)	t-value	p-value

Cd (µg/dl)	0.083±0.043	0.053±0.020	3.144	0.005
Lower 95% C.I	0.063	0.043		
Upper 95% C.I	0.103	0.063		
Pb(µg/dl)	12.43±3.77	9.76±2.61	3.399	0.003
Lower 95% C.I	10.66	8.56		
Upper 95% C.I	14.19	11.00		
Hg(µg/dl)	0.510±0.197	0.358±0.190	3.946	0.001
Lower 95% C.I	0.417	0.269		
Upper 95% C.I	0.602	0.447		
Cu (µg/dl)	120.7±5.36	119.1±5.47	0.098	0.923
Lower 95% C.I	95.60	93.5		
Upper 95% C.I	145.80	144.7		
Zn (µg/dl)	69.55±29.90	71.12±10.14	-0.273	0.784
Lower 95% C.I	55.55	66.37		
Upper 95% C.I	83.55	75.86		
Se (µg/dl)	27.23±13.66	16.02±13.77	2.114	0.048
Lower 95% C.I	20.83	9.57		
Upper 95% C.I	33.62	22.48		

Blood Heavy Metals and Trace Metals in Coffee Consumers versus Controls

Blood Cd, Pb, Hg, Zn and Se were significantly higher (p=0.001, p=0.000, p=0.012, p=0.037 and p=0.006 respectively) in Coffee Consumers compared with Controls. There were no significant difference in blood Cu (p=0.222) in Coffee Consumers compared with Controls (Table 2).

Table 2: Blood Heavy Metals and Trace Metals in Coffee Consumers versus Controls

VARIABLES (MEAN±SD)	**COFFEE CONSUMERS (n=20)**	**CONTROLS (n=20)**	**t-value**	**p-value**
Cd (µg/dl)	0.116±0.066	0.053±0.020	3.848	0.001
Lower 95% C.I	0.078	0.043		
Upper 95% C.I	0.141	0.063		
Pb (µg/dl)	12.28±2.83	9.78±2.61	14.231	0.000
Lower 95% C.I	10.96	8.56		
Upper 95% C.I	13.51	11.00		
Hg (µg/dl)	0.480±0.184	0.358±0.190	2.772	0.012
Lower 95% C.I	0.393	0.269		

Upper 95% C.I	0.566	0.447		
Cu (µg/dl)	106.80±29.77	119.10±54.76	-1.262	0.222
Lower 95% C.I	92.90	93.50		
Upper 95% C.I	120.70	144.70		
Zn (µg/dl)	91.61±40.09	71.12±10.14	2.238	0.037
Lower 95% C.I	72.84	66.37		
Upper 95% C.I	110.38	75.86		
Se (µg/dl)	25.57±13.28	16.02±13.77	3.076	0.006
Lower 95% C.I	19.35	9.57		
Upper 95% C.I	31.78	22.47		

4.3 Blood Heavy Metals and Trace Metals in Tea Consumers versus Coffee Consumers

There were no significant differences in blood levels of Cd, Pb, Hg, Cu, Zn and Se (p=0.154, p=0.459, p=0.662, p=0.226, p=0.080 and p=0.705 respectively) in Tea Consumers compared with Coffee Consumers (Table 3).

Table 3: Blood Heavy Metals and Trace Metals in Tea Consumers versus Coffee Consumers

VARIABLES (MEAN±SD)	TEA CONSUMERS (n=20)	COFFEE CONSUMERS (n=20)	t-value	p-value
Cd (µg/dl)	0.084± 0.043	0.110±0.066	-1.484	0.154
Lower 95% C.I	0.063	0.078		
Upper 95% C.I	0.104	0.141		
Pb (µg/dl)	12.43±3.77	12.28±2.83	0.193	0.459
Lower 95% C.I	10.66	10.96		
Upper 95% C.I	14.19	13.61		
Hg (µg/dl)	0.510±0.197	0.480±0.184	0.444	0.662
Lower 95% C.I	0.417	0.393		
Upper 95% C.I	0.602	0.566		
Cu (µg/dl)	120.70±53.66	106.80±29.77	1.246	0.228
Lower 95% C.I	95.60	92.90		
Upper 95% C.I	145.80	120.70		
Zn (µg/dl)	69.55±29.90	91.61±40.09	-1.849	0.080
Lower 95% C.I	55.55	72.84		
Upper 95% C.I	83.55	110.38		
Se (µg/dl)	27.23±13.66	25.57±13.28	0.384	0.705

Lower 95% C.I	20.83	19.35
Upper 95% C.I	33.62	31.78

4.4 Correlation of Blood Pb with Heavy Metals and Trace Metals in Tea Consumers

There were significant negative correlations of blood Pb with Hg and Cu(r=-0.451, p=0.046 and r=-0.697, p=0.001 respectively) and no significant correlations of blood Pb with Cd, Zn and Se(r=-0.209, p=0.377; r=0.067, p=0.778 and r=0.246, p=0.296 respectively) in Tea Consumers (Table 4).

Table 4: Correlation of Blood Pb with Heavy Metals and Trace Metals in Tea Consumers

Dependent Variables	N	r-value	p-value
Cd	20	-0.209	0.377
Hg	20	-0.451	0.046
Cu	20	-0.697	0.001
Zn	20	0.067	0.778
Se	20	0.246	0.296

Correlation of Blood Pb with Heavy Metals and Trace Metals in Coffee Consumers

There were significant negative correlations of blood Pb with blood Cu and Zn (r=-0.656, p=0.002 and r=-0.690, p=0.001 respectively) and significant positive correlation of Pb with Hg (r=0.538, p=0.017) in Coffee Consumers. There were no significant correlation of blood Pb with Cd and Se (r=-0.204, p=0.389 and r=0.380, p=0.099 respectively) in Coffee Consumers (Table 5).

Table 5: Correlation of Blood Pb with Heavy Metals and Trace Metals in Coffee Consumers

Dependent Variables	N	r-value	p-value
Cd	20	-0.204	0.389
Hg	20	0.528	0.017
Cu	20	-0.656	0.002
Zn	20	-0.690	0.001
Se	20	0.380	0.099

Correlation of Blood Cu with Heavy Metals and Trace Metals in Tea Consumers

There were significant negative correlation of blood Cu with Pb (r=-0.697, p=0.001), but significant positive correlation of blood Cu with Hg and Zn (r=0.662, p=0.001 and r=0.579, p=0.007 respectively) in Tea Consumers. There was no significant correlation of blood Cu with Cd (r=-0.104, p=0.663) in Tea Consumers (Table 6).

Table 6: Correlation of Blood Cu with Heavy Metals and Trace Metals in Tea Consumers

Dependent Variables	N	r-value	p-value
Cd	20	-0.104	0.663
Pb	20	-0.697	0.001
Hg	20	0.662	0.001
Zn	20	0.579	0.007
Se	20	-0.086	0.717

4.7 Correlation of Blood Cu with Heavy Metals and Trace Metals in Coffee Consumers

There were significant negative correlations of blood Cu with Pb and Hg (r=-0.656, p=0.002 and r=-0.590, p=0.006 respectively) and no significant correlations of blood Cu with Cd, Zn and

Se(r=0.268, p=0.254; r=0.472, p=0.036 and r=-0.087, p=0.715 respectively) in Coffee Consumers (Table 7).

Table 7: Correlation of Blood Cu with Heavy Metals and Trace Metals in Coffee Consumers

Dependent Variables	N	r-value	p-value
Cd	20	0.268	0.253
Pb	20	-0.656	0.002
Hg	20	-0.590	0.006
Zn	20	0.472	0.036
Se	20	-0.087	0.715

DISCUSSION

After water, tea and coffee, respectively, ranked the 1st and 2nd most widely consumed beverage in the world [17]. Coffee is planted in several countries [18], including Nigeria [19]. Coffee consumption varies widely according to geographical location, and seems to have distinct acute and long-term effects on health. Tea and coffee contains a number of beneficial health ingredients, such as trace elements, also contains undesired substances including heavy metals which can pose serious problems to human health because they are not biodegradable, remain in the environment and can become part of the food chain. The total metal concentration of the tea leaves and coffee beans depends on the influence of other factors,

including the properties of the soil. Despite the limited extent of metal migration from these plants to their prepared beverage forms, their pollution with metals such as lead, cadmium or mercury is not indifferent to human health.

From the present study, tea consumption may cause an increase in blood cadmium, lead, mercury and selenium (table 1). Also, c~~C~~offee consumption may lead to increase in blood cadmium, lead, mercury, zinc and selenium (table 2). Differences in the extent to which these beverages influence blood heavy and trace metal levels are subtle according to data from the present research (table 3).

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In the present study, the results of total contents of the studied heavy metals in both tea and coffee (Table 1-7) show the ability of tea and coffee plants to accumulate heavy metals which is reflected in the blood levels of these metals.

The reason behind the influence of tea and coffee consumption on blood concentrations of these metals resides in the fact that these metals can get into the tea and coffee plants through anthropogenic sources such as metal-containing pesticides, metal-containing fertilizers, and irrigation water with high levels of these metals. These metal contaminants may also get to tea plants through atmospheric deposition [20]. They eventually bioaccumulate higher up in the food chain and this makes humans to be at the receiving end. While there is a growing concern for adequate dietary availability of these elements, there has also been a growing awareness that excess exposure to nutritionally elements can be toxic [21].

It is worrisome that tea and coffee plants sometimes contains some beneficial elements in concentrations that are higher than would naturally occur [20]. When this happens, they are said to be contaminated. The chemical composition of coffee is very complex and depends on the

place of origin and species/cultivar of the coffee plant [22]. The technology used in the preparation and industrial processing of green beans, as well as the methods consumers use to prepare their coffee modify the concentrations of the substances in the final product. Additionally, potential contamination may derive from package and storage [23].

Some batches of tea can also be significantly contaminated with toxic metals, but even trace amounts of cadmium, arsenic and mercury are a threat for humans. Their provisional tolerable weekly intake from all sources (PTWI – Provisional Tolerable Weekly Intake) is determined by the Joint FAO/WHO Expert Committee [24].

This study showeds that there were no significant differences in blood levels of Cd, Pb, Hg, Cu, Zn and Se in Tea Consumers compared with Coffee Consumers (Table 3). It can be deducedseems that both Tea and coffee consumption affect the blood levels of these metals in similar pattern. It has been previously documented that these heavy metals and trace metals are contained in both tea and coffee. However, there is large variation in the elemental composition of tea [25] due to differences in climate and agricultural practices, including soil, water and fertilizers [26].

It has been previously noted that exposure to heavy metals above the permissible level can cause high blood pressure, fatigue, as well as kidney and neurological disorders. Heavy metals are also known to have harmful reproductive effects [27].

Conclusion

This study concludes that Tea and Coffee consumption may be associated with higher blood levels of some heavy metals and trace metals. Cultivation of tea and coffee plants should be done under strict control to check irrigation practices, use of fertilizers and herbicides which are a

significant source of toxic metal exposure. Also, tTea and coffee farms should be cited far from industries and factories in general so as to eliminate or reduce contamination .

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