Determination of Caffeine Content in Two Varieties of Kola Nut and Some Tea Products Sold in Lafia, North Central Nigeria

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ABSTRACT

Kola nuts, tea, and beverages are some of the caffeine containing products which are widely consumed all over the world. The caffeine serves as a stimulant and flavoring agent in food and pharmaceutical industries. This study investigated the amount of caffeine present in Kola nitida, Bitter kola, Lipton tea, Green tea, Milo, and Nescafe sold and consumed in Lafia town, North Central Nigeria. Caffeine contents were determined using standard method. From the results obtained, the amount of caffeine in kola nitida was found to be 1.15 mg/L. This was the highest compared to other sampled products. Others included Nescafe (0.41 mg/L), Lipton tea (0.22 mg/L), Green tea (0.21 mg/L), Bitter Kola (0.18 mg/L), and Milo (0.04 mg/L). All the samples analyzed were observed to be low in caffeine content. The US Food and Drug Administration recommends a daily intake of no more than 200-400 mg. Above this limit will result in health implications. The results from the sampled products indicates safety of several daily consumptions as bioaccumulation of caffeine may not fall below the 200 mg and will certainly not exceed the 400 mg threshold. Thus, it can be said that taking kola nuts or these beverages several times in a day may not pose any health problems.

(Keywords: kola nuts, caffeine, tea, beverages, bioaccumulation).

INTRODUCTION

Caffeine (1,3,5-trimethylxanthine) is an alkaloid that belongs to the methylxanthine family which is found in leaves, seeds, or fruits of over 63 different plant species (Okoli, *et al.,* 2012). It has specific relationship with theobromine and theophylline. The most important known sources of caffeine are coffee (*Coffea* spp.), tea (*Camellia sinensis*), guarana (*Paullinia cupana*), mate (*Ilex paraguariensis*), Cola nuts (*Cola vera*), and cocoa (*Theobroma cacao*).

Reports show that the percentage composition of caffeine in some of the natural product varies – the highest amounts are found in guarana (4–7%), followed by tea leaves (3.5 %), mate tea leaves (0.89–1.73 %), coffee beans (1.1–2.2 %), cola nuts (1.5 %), and cocoa beans (0.03 %) (Clifford and Ramirez-Martinez, 1990; Komes, *et al.,* 2009). Some beverages and soft drinks are produced from raw materials containing caffeine.

There are some products which are sold in market that are scientifically proven to contain caffeine in them. Examples include Nescafe, Milo, Green tea, Bitter kola and Kola nitida. The presence of caffeine in these products contributes to their daily intake by human as a psychoactive substance.

Caffeine is a natural product which is a colorless, crystalline solid that melts at 235-236 ^{0}C but has the ability to sublime under reduced pressure at a temperature below its melting point. It is more soluble in organic solvent but moderately soluble in water (2.2g/100 mL). It has a chemical formula of $C_8H_{10}N_4O$ (Komes, *et al.,* 2009). Caffeine is slightly soluble in some organic solvents such as petroleum ether and Benzene but shows moderate solubility in alcohols and acetone. At 178 ^{0}C pure caffeine sublimes, thus having a pH value that ranges from 6.5 to 10.4 (Yunus, Nulamuga, 2020; Vallambroso, 2006; and Belay, 2011).

Caffeine is a pharmacological and psychoactive stimulant which is dose-dependent. Being a stimulant, it aids alertness and focus, promotes metabolism, energize the body, ease fatigue, elevates mood, and contributes to efficient performance of athletes (Ogah and Obebe, 2012;

Lovett, 2005). Caffeine is also employed in humans as supplements which aids weight loss as a result of its capacity to act as an appetite suppressant and in invigorating thermogenesis. Some of the analgesic drugs used as pain relievers, headache remedies and antihistamines are known to contain caffeine.

Some regulatory agencies such as U.S. Department of Agriculture (USDA) and European Food Safety Authority (EFSA) stated the concentration of caffeine that is safer to adults with no health challenges to be 300-400 mg per day (Richling *et al.,* 2014). The US Food and Drug Administration (USFDA) indicated that caffeine consumption below 130 - 300 mg/day is low/moderate whereas above an intake above 400 mg/day is high (U.S. Code of Federal Regulations, 2003; Ogah and Obebe, 2012).

Caffeine is one of the most commonly consumed substances in the world today. Several researchers have shown that caffeine stimulates the central nervous system. Due to its pharmacological properties, it has the ability to increase heart rate, enlarge blood vessels, and enhance the degree of free fatty acids and glucose in plasma (Igelige, *et al.,* 2014). Reports show that if caffeine intake exceeds the acceptable limits, symptoms such as restlessness, over excitement, difficulty in sleeping, muscular tension, irritation, and cardiovascular disturbances will certainly occur (Yunus and Nulamuga, 2020 and Aragao, *et al.,* 2005).

Previous studies investigated that, consistent intake or drinking caffeine even without exceeding the amounts needed by human; can cause chronic headaches and migraines (Gebely, 2017). Mumin, *et al.* (2006), reported that; every time we drink tea, coffee, cocoa, chocolate, or cola, we are giving our body a hit of caffeine.

Igelige, *et al.* (2014), reported that 1 g of caffeine leads to insomnia, nervousness, nausea, ear ringing, flashing of lights, delirium, and tremulousness. Some studies also revealed that an excessive intake of caffeine with alcohol, some narcotics drugs could be detrimental to the health and in some cases might result in death (Igelige, *et al.,* 2014 and Wanyika, *et al*., 2010).

Consumption of any raw material containing caffeine shows that the plasma half-life of caffeine is 6 hours before undergoing bio-transformation and excretion. This indicates that some of the metabolites cannot be completely excreted from gastro-intestine, only 50% of caffeine concentration can be removed from the body as waste product (Yunus and Nulamuga, 2020). Thus, a cup of coffee with 150 mg of caffeine when consumed at 3 pm, will still have approximately 75 mg of the caffeine remaining in the body at 9 pm (Khalida, *et al.,* 2006 and Allgeier, *et al.,* 2003).

Lindsey (2005) and Belay (2011) reported that the absorbability of caffeine in the gastrointestinal tract is swift and it takes a short period of time for it to circulate within the body. Caffeine in the body is metabolized first into paraxanthine and thyobromine before undergoing circulation which are later converted into uric and diaminourcil and then eliminated from body (Yunus and Nulamuga, 2020).

Kola is a natural source of caffeine, the two common species are Kola nitida and Bitter kola. The nut has sweet smell. At first the taste is bitter but sweetens upon chewing. The nuts are eaten whole or powdered. Due to the caffeine content in Kola, some people take or chew it in order to induce wakefulness when arising from sleep or to prevent falling asleep at specific times and to relieve the boredom of daily routines and to ease hunger pangs (Ogah and Obebe, 2012).

Kola nut has a wide application in several human social activities, these include ancestors' venerations, ceremonies, weddings, and funerals. It also serves as an active ingredient used for the flavoring of chocolates, soft drinks, and other non-alcoholic beverages (Yalwa and Bello, 2017).

Tea is one of the most consumed beverages in the world because of its pleasant taste, aroma, flavor, and potential health-promoting properties. Studies indicate that tea has the propensity to reduce cholesterol levels, reduce the risk of developing hypertension, immune disorders and Parkinson's disease. The caffeine content in tea is dose dependent and can be harmful to humans if consumption exceeds the recommended level of caffeine content (Yalwa and Bello, 2017).

Kola and beverages have gained their popularity in the world and in Nigeria, they are mostly consumed in the northern part at any and at several times a day. In this regard, it becomes

pertinent to know the caffeine content of these kola nuts and tea items so as to guide against exceeding the daily allowed dosage.

MATERIALS AND METHOD

Sample Collection

Kola nitida, Bitter kola, Green tea, Nescafe, Lipton, and Milo were bought in Lafia Open Market located at the central part of Lafia town, North Central Nigeria.

Preparation of Kola Nut

The Kola nuts were washed, weighed, and steamed in a beaker at atmospheric temperature of 92-100 ^{0}C for two hours. After steaming, the nuts were allowed to cool before being discharged into a basin. The samples were manually sliced and placed in an oven (DHG-9010. SA) at 105 ^{0}C for 3 hours until a constant weight was obtained. The dried samples were grounded using a manual grinder and were stored in a desiccator.

Preparation of Standard Solution (Pure Caffeine)

A 100 ppm standard solution of caffeine was prepared by dissolving 100 mg of powdered caffeine in 100 ml distilled water. Working standards were prepared by pipetting 5, 10, 15, 20, and 25 mL aliquots of the stock standard solution into separate 100 mL volumetric flasks and diluting to volume with distilled water and stirred using magnetic stirrer for 30 seconds. The various concentrations were subjected to UV/Visible spectrophotometer to obtain the respective absorbance values. The calibration cure of the pure caffeine was then obtained by plotting the Absorbance values against their respective concentrations.

Caffeine Extraction from Kola, Green Tea and Beverages

One gram (1g) each of the samples was weighed using electronic weighing balance. Distilled water (200mL) was added into the various samples measured and were shaken for 15 minutes using a magnetic stirrer. The mixture was filtered using Whatman filter paper.

A 10 mL portion of the filtrate was measured into 50 mL chloroform. The chloroform layer was then separated from the water layer by centrifugation. The centrifuge speed was set at 300 rpm. The layer was filtered and the filtrate was evaporated to dryness. The residue after evaporation was re-crystallized as white powder ((Mp 230 ^{0}C). The residue obtained was dissolved in 50 mL of water, warming gently on a water bath.

The solution was cooled in a desiccator and was made up to the mark of 100 mL. The absorbance of the resulting solution was then measured using a UV/Vis spectrophotometer at 276 nm (Ogah and Obebe, 2012). Liquid-liquid extraction technique described by Williams and Katherine (2011), was used to extract the caffeine content from green tea leaves.

RESULTS AND DISCUSSION

Table 1 and Figure 1 show the absorbance of the various concentrations of pure caffeine and the standard calibration curve obtained. Table 2 gives the concentration of caffeine in the two varieties of Kola nut and some tea products and beverages.

DISCUSSION

Table 2 shows the amount of caffeine present in the respective varieties of kola nut and tea products sampled. Kola nitida, of all the samples analyzed, had the highest concentration of caffeine (1.15 mg/L) while Milo (0.04 mg/L) had the least amount.

In terms of percentage caffeine content, Figure 2 shows the samples of Kola nitida, Bitter kola, Nescafe, Lipton, Milo and Green tea to be 46.0, 16.24, 8.68, 8.36, 7.4, and 1.56 %, respectively. The amount of caffeine in the experimental samples varied according to the type of product and possibly the method of preparation. The percentage composition of caffeine in Kola nitida in this study was very high when compared to the values reported by Okoli, *et al.* (2012). Yalwa and Bello (2017), had a caffeine content of 2.4 %.

Table 1: Absorbance of Different Concentrations of Pure Caffeine.

S/N	Caffeine (mg/L)	Absorbance at 276 nm
1	25	1.20
2	20	0.94
3	15	0.75
4	10	0.48
5	5	0.21

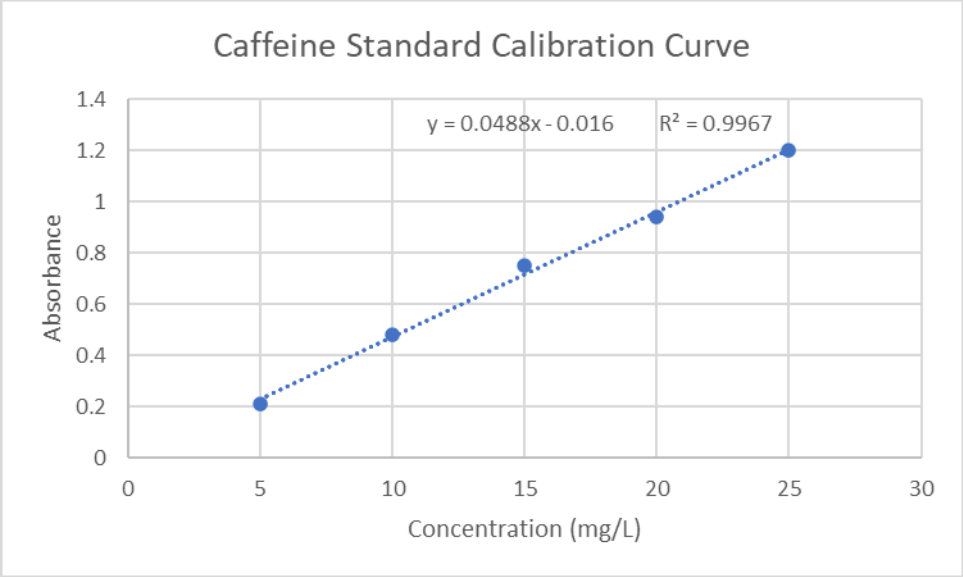

Figure 1: Calibration Curve of Pure Caffeine.

Table 2: Concentration of caffeine in two varieties of Kola nut and some tea products

S/N	Samples	Absorbance at 276 nm	Concentration of Caffeine (mg/L)	Caffeine Percentage (%)
1	Kola nitida	0.550	1.150	46.0
2	Bitter kola	0.074	0.184	7.40
3	Nescafe	0.182	0.406	16.24
4	Lipton	0.090	0.217	8.68
5	Milo	0.003	0.039	1.56
6	Green tea	0.086	0.209	8.36

Similar studies by Komes *et al.,* (2009); and Athayde *et al*. (2000) attributed the variations in the caffeine content in the analyzed samples to their origin, generic and environmental factors, method of processing and time of harvest.

The USFDA stated that caffeine consumption below 130 - 300 mg/day is low/moderate, whereas, above an intake of 400 mg/day is high (U.S. Code of Federal Regulations, 2003; Ogah and Obebe, 2012). Since the intake or consumption of caffeine products like chewing as with kola nuts or drinking as with tea or beverage consumption, can possibly result in daily accumulation which may very well over shoot the maximum permissible limit, and invariably pose health challenges, it is important to know or have an idea of the caffeine content of these samples or products.

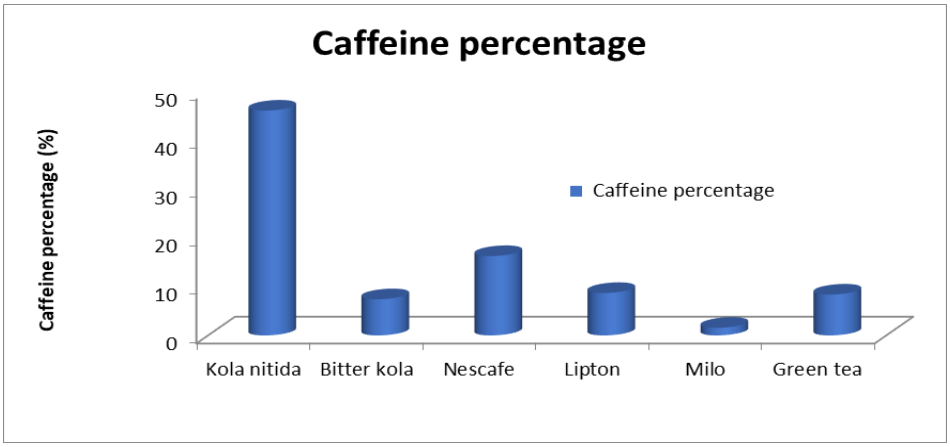

Figure 2: Showing the Percentage of Caffeine in Two Varieties of Kola Nut and Some Tea Products.

The results obtained in this study, showed that all the samples analyzed generally had low caffeine contents and several consumptions of these products in a day either by chewing or as beverages was safe as accumulation above the threshold limit may not be practicable.

It should be noted that Kola nitida which was 46 % or 1.15 mg/L of caffeine and was found to be the highest, although this value was still generally low. This is because a 200 times consumption of it per day would still not exceed the threshold limit of 400 mg. Since caffeine is dose dependent, the excessive consumption of Kola nitida and other products containing caffeine should be avoided by people suffering from high blood pressure and other cardiovascular diseases as the excessive intake can cause adverse health effects. However, it is pertinent and necessary that the intake of caffeine-containing edible food substances and beverages should be regulated and most importantly, the specific amount of the caffeine content be explicitly written on the label.

CONCLUSION

The concentration and percentage of caffeine in two varieties of Kola nut and some tea products were investigated. This study indicated that Kola nitida (46 %) and Nescafe (16.24 %) had the highest caffeine content while Bitter kola (7.4 %) and Milo (1.56 %) recorded least among the samples analyzed. The caffeine content in the samples were far below the USFDA threshold limits. The implication is that samples analyzed could be taken several times a day without fear of accumulation above the threshold or safety limit of 400 mg/day. There was also a wide disparity between the two varieties of kola nuts with the Kola nitida (1.15mg/L) and Bitter kola (0.18 mg/L), respectively

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