Communication in Physical Sciences, 2023, 9(2):106-110

Ultraviolet-Visible Spectrophotometric Determination of Caffeine in Different Tea Samples

Martins Moses, Andy N.M., John Stanley, Muslim U. Abdullahi, Benjamin Biko, Silas Ishaku, Adam Aliyu and Christiana O. Albert

Received: 22 January 2023/Accepted 24 April 2023/Published online: 05 May 2023

Abstract: *Caffeine (1,3,5-trimethylxanthine) contents fromseventeen brands of black and green tea that are common in Yobe State, Nigeria were extracted and analysed for their concentration usingan Ultraviolet-Visible spectrophotometer. The results indicated caffeine concentration in the range of 347 ppm (in Akbar tea) to 770 ppm (in Sultan tea). The relative concentration of caffeine in the analyzed samples ranked as follows, Sultan (770 ppm) > Lipton yellow label (733 ppm) > Amar (728 ppm) > Shams Green Tea (712 ppm) > Tea Pot (699 ppm) >Ahdar (670 ppm) > Nana Tea (666 ppm) > Apple Black Tea (649 ppm)> Ahmed Tea(639 ppm) > Lipton Clear Green (599 ppm) > Tea Shop (564 ppm)> Tetley (553 ppm) > Accord (508 ppm) > Tiger (388 ppm)> Top Tea (378 ppm)> Beyond Comment (365 ppm) > Akbar (347 ppm). The caffeine contents in the tea samples analyzed in this study were below the maximum recommended limits for consumption and may not present an immediate health challenge except if excessive consumption is administered within a short period.*

Keywords: Determination, caffeine, tea samples in Yobe, UV-Vis analysis

Martins Moses*
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email: mrtnsmss@gmail.com

Andy NyakoMoses
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email: revandymoses@yahoo.com

John Stanley
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email:stanleyjohn45@gmail.com

Muslim Usman Abdullahi
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email: muslimusman1@gmail.com

Benjamin Biko
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email:bikoben3@gmail.com

Silas Ishaku
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email:labicity@gmail.com

Adam Aliyu
Department of Chemistry, College of Education, Zing, Taraba State, Nigeria
Email: adamaliyu2000@gmail.com

Christiana Oyime Albert
[7]Department of Pure Sciences, Taraba State Polytechnic, Suntai, Nigeria
Email: kristyoyime@gmail.com

1.0 Introduction

Tea (*Camellia sinensis*) is a very popular beverage in the world and is consumed by over two-thirds of the world's population. A typical cup of tea is prepared by brewing one tea bag (1.8–2.4 g tea) in 200–250 ml of hot water for 3–5 min. The three major types of teas which are commercially produced from tea leaves and differ only in their processing methods include; green tea, oolong tea and black tea (Alan and Iris, 2004).

Caffeine (1,3,5-trimethylxanthine) is an alkaloid that is responsible for the stimulating effects of tea. It is a mild nervous stimulant that some people claim improves mental alertness, decreases fatigue and enhances performance (Bruin *etal.,* 2011). Increased public awareness of the health-protective characteristics of tea, which are generally considered to be associated with caffeine and the high flavonoid content of the leaves and extracts, has contributed to the public's general attitude toward the beverage. The consumption of tea has been associated with a decreased risk of developing cancer of the stomach, and coronary heart disease and a reduced incidence of stroke (Fisone*et al*,. 2004; Larson, 2009; Yang, 2001) However, like other methylxanthines (theobromine and theophylline), caffeine has physiological and pharmacological effects on some body systems, including the central nervous, cardiovascular, gastrointestinal, respiratory and renal systems (Nehlig*etal.*, 1992; Mostofsky*etal*. 2012). Studies conducted by Fisone*etal*.(2004), Nehlig*etal.* 1(992) and Mrvos*etal*.(1989) have also shown that some sensitive individuals experience side effects such as insomnia, irritability, sleeplessness, nervousness and even death.

2.0 Materials and Method

Seventeen commonly consumed commercial tea samples made up of fifteen black tea samples (Sultan, Lipton yellow label, teapot, Akbar, Apple black tea, Ahmed tea, Tea shop, Tetley, Tiger, Top Tea, Beyond comment,Amar, Nana tea, Accord and Ahdar tea) and two green tea samples (Shams green tea and Lipton clear green), were purchased from supermarkets and local market in Damaturu, Nigeria.

2.1 Extraction of caffeine

50g of Lipton Yellow Label tea was accurately weighed and transferred into a 500ml conical flask. Distilled water (300ml) was added and boiled for 20 minutes. The solution was filtered and a little amount of lead acetate was added to the filtrate till a curdy brown-colored precipitate was formed. The lead acetate was added continuously till no precipitate was formed. The solution was filtered and heated until the volume was reduced to 50ml. The filtrate was cooled to room temperature and transferred into a separating funnel. Fifty (50) ml of chloroform was added into the funnel and shaken. Once the chloroform and water layers have been separated, the organic layer was drained into a 50 ml conical flask. The extraction was repeated twice, each with fresh 50 ml chloroform. The combined organic layers were then filtered into a dry pre-weighed 100 ml conical flask. The solution was evaporated to dryness on a steam bath and weighed to determine the weight of the crude caffeine. The crude caffeine was recrystallized from 95% ethanol and the melting point of the pure caffeine was determined. Pure caffeine was tested based on standard procedures(Palleros, 2000).

2.2 Preparation of standard caffeine solution

The caffeine stock solution (1000ppm) was prepared by dissolving 100mg of pure caffeine in 100ml of distilled water. Caffeine working standard solutions (10, 20, 30, 40, 50, 60, 70, 80, 90, and 100ppm) were prepared by serial dilution of the stock in a 25ml volumetric flask. One ml (1 ml) of 1.0mol of HCl was added to each and made up to the mark with distilled water.

UV/Vis Spectrophotometer (JENWAY Model 6305) was used to determine the wavelength of maximum absorption (λ max) by scanning 10 ppm of the prepared standard solution from 200-500 nm to obtain the absorption spectrum. A plot of Absorbance against wavelength was plotted to get the λ max which was characterized by a single intensive absorption band at 274nm.

The absorbance of each of the prepared caffeine standard solutions was measured at λ_{max}= 274 nm. The absorbance values were

then plotted against concentrations to generate a caffeine standard calibration curve (Fig. 1).

2.3 Determination of caffeine in the tea samples

A sample of 0.25 grams of tea was dissolved in 20ml distilled water and transferred into 250 ml flask. Ten (10) ml of 0.01M hydrochloric acid, 2 ml basic lead acetate solution were added and made up to the mark with distilled water. The mixture was shaken and filtered to clarify. Fifty ml (50 ml) of the filtrate was pipetted into a 100 ml volumetric flask followed by the addition of 0.2 ml of 4.5M sulphuric acid and made to the net volume with distilled water, shaken and filtered. All the tea samples were prepared similarly and the absorbances of the samples were measured on the UV/ Vis spectrophotometer at 274 nm using 10 mm quartz cuvette.

3.0 Results and Discussion

The calibration curve (Fig. 1) was obtained using a computer Microsoft excels and the curve illustrates a positive linear relation between absorbance and the concentrations of the caffeine standards. The caffeine levels of the tested tea samples were estimated from the standard curve and the results are presented in Fig. 2.

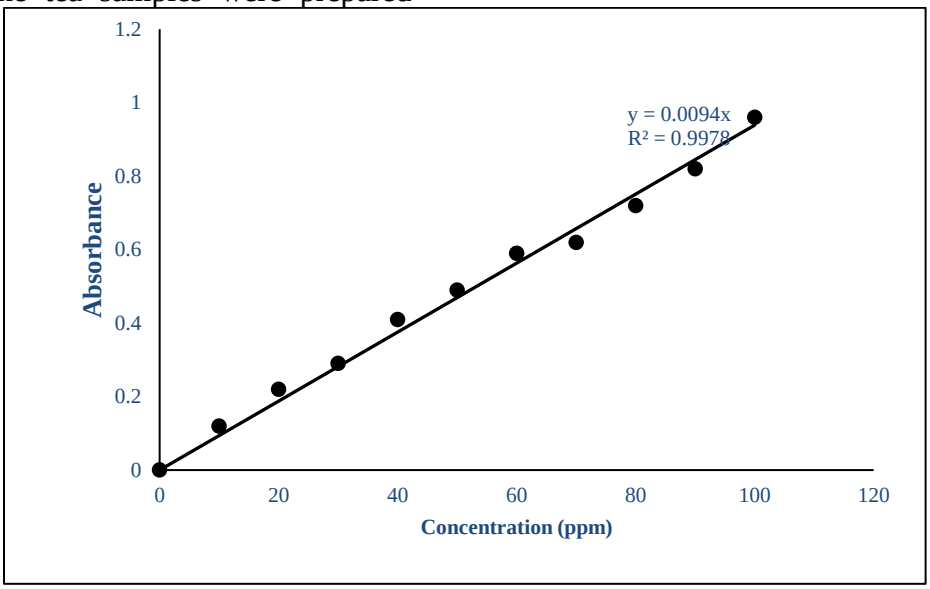

Fig. 1: Calibration curve for standard caffeine

Although caffeine levels are affected by the tea blend, preparation method and brewing time, the results demonstrate that the black tea samples such as Lipton yellow label (Lyl) (733ppm) and Sultan (Slt) (770ppm) which are popular contained the highest amounts of caffeine while Akbar tea (Akt) (347ppm) and Beyond comment (Bct) (365ppm) contained lowest caffeine concentrations. These variations are in agreement with previous work on caffeine levels in tea reported by Tadelech and Gholap (2011). The levels of caffeine in the green tea samples were appreciably higher than some of the black tea samples but lower than the levels in Lyl and Slt teas. Lin *et al*. (1998) reported that fermented teas (black teas) contained high levels of caffeine compared to green teas. Our results are comparable to the caffeine levels in white, green and black teas which ranged from 14-61 mg per serving with no observable trend in caffeine concentration based on the variety of tea reported by Cusker *et al*. (2008).

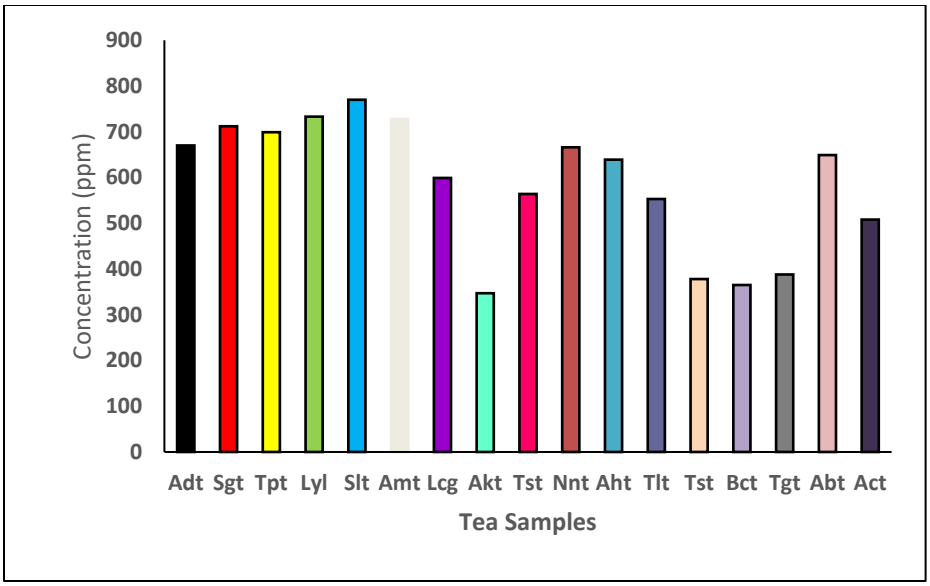

Fig. 2: Caffeine contents in the tea samples

A moderate daily caffeine intake is generally understood to be about 300mg/day which is about 6 cups of brewed hot tea or 3 cups of coffee /per day for an adult. Therefore despite the variations in levels of caffeine in the tested tea samples, the levels were within the recommended limits for consumption.

4.0 Conclusion

This study provides information regarding the caffeine content of different brands of tea sold and consumed in Damaturu and its environs. Based on this study, Sultan tea was recognized to be the richest source of caffeine while Akbar tea contained the least caffeine level but all the samples were within the recommended caffeine limits for human consumption. Therefore a moderate tea consumption ranging from 3 to 5 cups per day is unlikely to be of any health concern. However, caffeine should be treated as any other drug and high caffeine-content foods should be used with caution until a person understands how it interacts with his/her particular genetic makeup and health profile. It is also important to understand that a person's safe limit of caffeine can change over time as a person's health evolves over his lifetime.

Furthermore, it was observed that all the packaged tea samples analyzed carried nutritional information but caffeine contents were not indicated. Therefore regulatory agencies like NAFDAC (National Agency for Food and Drug Administration and Control) and SON (Standard Organization of Nigeria) may wish to consider advising tea manufacturers to list caffeine levels on labels to guide consumers on the type of tea to buy.

5.0 References

Nehlig, A., Daval, J. L. & Deby, G. (1992). Caffeine and the central nervous system: Mechanisms of action, biochemical, metabolic, and psychostimulant effects. *Brain Res Rev.* 17, 2, pp. 139-170.

Tadelech A. & Gholap A.V(2011). Characterization of caffeine and determination of caffeine in tea leaves using UV-visible spectrophotometer. *African Journal of Pure and Applied Chemistry*. 5, 1, pp. 1-8.

Yang, C. S., Landau, J. M. Huang, M. T. & Newmark, H. L. (2001). Inhibition of carcinogenesis by dietary polyphenolic compounds. *Ann. Rev Nutr*, 21, pp. 381-406.

Palleros, D. R. (2000). *Experimental Organic Chemistry*. JOHN Wiley and Sons, Inc., pp. 103-112.

Mostofsky, E., Rice, M. S. Levintan E. B. & Mittleman M.A. (2012). Habitual coffee consumption and risk of heart failure: a dose- response meta-analysis. *Circ. Heart Fail*. 5, 4, pp.401-405.

De Bruin, E. A. Rowson, M. J. Van Buren, L. Rycrof, J. A. & Owen, G.N. (2011). Black tea improves attention and self-reported alertness. *Appetite*. 56, pp. 235-240.

Fisone, G. Borgkvist, A. & Usiello. A. (2004). Caffeine as a psychomotor stimulant: mechanism of action. *Cell Mol Life Sci* 61 (7-8): pp. 857-872.

Lin, J. K. Lin, Y. L., Liang, Y. C Shiau, S. Y. L. & Juan I. M. (1998). Survey of catechins, gallic acid and methylxanthines in green, oolong, Pu-erh and black teas. *J. Agric. Food Chem*. 46, pp. 3635-3642.

Alan, M. & M. Iris, M. (2004). *Green Gold: The Empire of Tea.* The Overlook Press, Woodstock and New York. 320pp.

Mrvos, R. M., Reilly, P. E., Dean, B. S. & Krenzelok, E. P. (1989). "Massive caffeine ingestion resulting in death". *Vet. Hum. Toxicol.* 31, 6, pp. 571.

Mc Cusker, R.R. Goldberger, B. A. & Cone, E.J. (2008). Caffeine Content of Brewed Teas. *Jour. Anal. Toxicol*. 32, pp. 702-704.

Larson, S. C. Virtamo, J. & Work, A. (2009). Black Tea Consumption and Risk of Stroke. A meta-analysis. *Stroke.* 40, 5, pp. 1786-1792.

Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data public

Competing interests

The authors declared no conflict of interest.

Funding

There is no source of external funding

Authors' contributions:

Martins Moses designed the work, AN Moses partake in writing the first manuscript. J. Stanley, MU Abdullahi, B. Biko, S. Ishaku, A Aliyu, C. O. Albert where involved in the analysis, samples collections and identification