A Comparative Study of Caffeine Levels in Coffee and Cocoa in Kenyan Supermarkets and Shops

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Abstract

Background: Caffeine is an alkaloid belonging to the methylxanthine family. An overdose of caffeine causes the following side effects: restlessness, nervousness, excitement, insomnia, flushed face, diuresis, gastrointestinal disturbances, muscle twitching, rambling flow of thought and speech, and tachycardia or cardiac arrhythmia. This study aimed to determine the caffeine levels of various brands of coffee and cocoa and enlighten people on the safe and healthy consumption of the two products.

Methods: Different brands of coffee and cocoa products were randomly sampled and purchased from supermarkets and shops in Nairobi, Kenya. Five samples of coffee and four brands of cocoa were purchased from a supermarket and taken to the laboratory for analysis. Caffeine was extracted, and quantitative analysis was done using High Performance Liquid Chromatography (HPLC).

Results: The study found that coffee has a higher concentration of caffeine than cocoa. Coffee Brand A recorded the lowest level of caffeine with 30.9845 µ g/g, while Coffee Brand C recorded the highest level of caffeine with 426.9639 µ g/g. Among the Cocoa brands, Cocoa Brand B recorded the lowest level of caffeine (2.6367 µg/g), while Cocoa Brand C recorded the highest level of caffeine at 19.03 µ g/g.

Conclusion: Therefore, there is a need to reduce coffee consumption per day because caffeine overdose can cause high blood pressure and other illnesses. Cocoa is recommended for consumption since it contains less caffeine per serving.

Keywords: Caffeine, coffee, cocoa, Kenya

Introduction

Caffeine is a natural stimulant that is present in coffee and cocoa. Caffeine-containing beverages have long been integral to cultural traditions and daily life (Albuquerque & Smith, 2017). However, beyond its sensory pleasures, understanding the contents and quality of these beverages, coffee, and cocoa is crucial for consumer health (Heckman *et al.,* 2010). In Kenya, the consumption of coffee and cocoa is deeply ingrained in the culture, making it essential to determine the precise caffeine levels in various brands (Kenyan Coffee Association, 2018). Consumption choices extend beyond personal taste, encompassing broader concerns, such as health implications,

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consumer preferences, and adherence to regulatory standards (Karkera *et al.*, 2023). As awareness of the health impacts of caffeine increases, consumers are becoming increasingly conscious of their caffeine intake (Albuquerque & Smith, 2017). Like many other nations, Kenya has established regulations governing caffeine-containing products, emphasizing the need for adherence to ensure consumer safety and industry credibility (Kenya Bureau of Standards, 2019). Ensuring compliance with these regulations is vital for maintaining the integrity of product labeling and preventing excessive caffeine levels (Albuquerque & Smith, 2017).

Despite the growing importance of monitoring caffeine levels, there is a significant research gap concerning the precise caffeine content in coffee and cocoa available in Kenyan markets (Brown, 2018). This gap poses potential health risks to consumers and undermines the industry's credibility. This study aims to address this gap by systematically analyzing caffeine levels in coffee and cocoa available in some brands sold in Kenyan supermarkets and shops. Additionally, it seeks to provide consumers with valuable information, promote economic stability, and advance scientific knowledge (Green & Black, 2020). This research is timely, given the increasing popularity of coffee and cocoa in Kenya, a growing awareness of healthy lifestyles among consumers, and the global rise in health issues linked to caffeine consumption (Gabrielle *et al.*, 2020).

Literature Review

Consumer awareness of the potential health effects of caffeine has led to increased scrutiny of its intake (Lieberman, 2021). Although caffeine consumption can enhance cognitive function, alertness, and athletic performance (Albuquerque & Smith, 2017), excessive consumption has been linked to adverse effects, including insomnia and anxiety (Nawrot et al., 2003; Martins et al., 2023). Therefore, consumers need accurate information about the caffeine content in the products they consume (Green & Black, 2020).

In Kenya, coffee is of significant cultural and social importance. There is a growing awareness of the impact of caffeine on health, particularly among urban consumers who frequent coffee shops and buy cocoa-based products (Karkera et al., 2023). This growing awareness highlights the need for precise caffeine content analysis to help consumers make informed choices (Albuquerque & Smith, 2017). Kenya's regulations on caffeine-containing products underscore the importance of compliance in ensuring consumer safety and industry credibility (Kenya Bureau of Standards, 2019). Accurate analysis of caffeine content is critical for reliable product labeling and prevention of excessive caffeine levels (Brown, 2018).

Various studies have explored analytical techniques for caffeine quantification, including High-Performance Liquid Chromatography (HPLC) and spectrophotometry (Heckman et al., 2010; Poole & Poole, 2020). These studies have significantly contributed to our understanding of caffeine analysis (Green & Black, 2020). Additionally, previous studies have highlighted the geographic variations in caffeine content due to factors such as origin and altitude (Jha & Mohanty, 2015).

Consumer preferences regarding caffeine content in coffee and cocoa beverages have been explored in numerous studies (Heckman et al., 2010). Understanding these preferences can assist businesses in tailoring their product offerings (Albuquerque & Smith, 2017). However, there is a research gap in Kenya, particularly in quantifying caffeine content in products available in Kenyan supermarkets and shops (Brown, 2018). This gap leaves consumers without adequate information, challenges industry compliance with Kenyan regulations, and affects industry credibility (Karkera et al., 2023). This study addresses this gap by systematically analyzing the caffeine content in a wide range of coffee and cocoa products available in Kenyan supermarkets and shops. It provides accurate information to consumers, supports industry compliance, and advances scientific knowledge within the Kenyan context (World Health Organization [WHO], 2020).

Methodology

Research Setting

This study was conducted in Nairobi, Kenya between year 2010-2011. The samples were collected from shops and supermarkets such as Naivas, Tuskys, and Magunas. They were then taken to Jomo Kenyatta University of Agriculture and Technology (JKUAT) laboratories for chemical analysis using a High-Performance Liquid Chromatography (HPLC) instrument.

Sampling

Different brands of coffee and cocoa products were randomly sampled and purchased in the supermarkets and shops in Nairobi, Kenya. Five brands and four brands of coffee and cocoa were sampled and purchased from the supermarket. Three samples were obtained for each brand; therefore, 15 coffee samples and 12 cocoa samples were obtained. The samples were taken to the laboratory for analysis. Similar brands (3 for each brand) were homogenously mixed before the sample analysis.

Preparation of the Mobile Phase

One liter of the mobile phase was prepared using 200 mL of methanol, 790 mL of water, and 10 mL of acetic acid in the ratio of 20:79.9:0.1, respectively. Approximately 500 mL was filtered, degassed, and used as the mobile phase, whereas the rest was used to prepare dilutions of the standards and samples.

Preparation of the Stock Standard Solutions

The standard stock solution was prepared by weighing 100 mg of caffeine and quantitatively transferring it into a 100 mL volumetric flask. The mobile phase was added to a 100 mL mark, making the concentration 1 mg/mL solution.

Preparations of the Working Standard Solutions

Working standards ranging from 10 to 80 µg/mL were prepared by dilution with the mobile phase.

Sample Preparation

Two grams of cocoa/coffee were weighed and placed in a 250 mL beaker. Then 100 mL of boiling water (distilled) was added, and the mixture was allowed to stand for 5 min while stirring. It was then cooled and filtered into a conical flask; 4 mL of the filtrate was pipetted into a clean 10 mL volumetric flask and made up to the mark with the mobile phase. The samples were all prepared in the same way, in triplicates. We made note of all dilutions.

Data Collection and Analysis

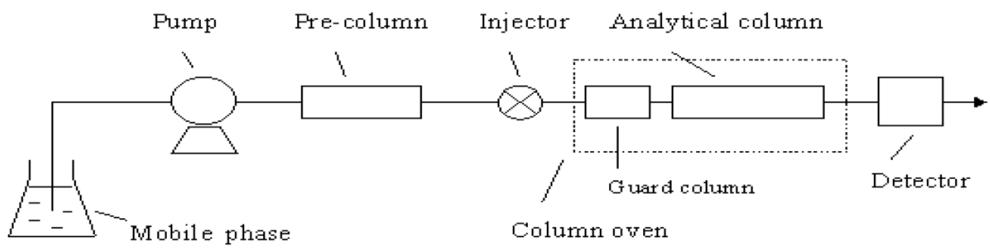
Chemical analysis of the caffeine levels in the samples was carried out using High-Performance Liquid Chromatography (HPLC) as shown in Figure 1. The HPLC method was chosen for determining caffeine levels because it has several advantages, such as (1) high resolving power, (2) rapid separation, (3) continuous monitoring of the column effluent, (4) accurate quantitative measurement, (5) repetitive and reproducible analysis using the same column, and (6) automation of the analytical procedure and data handling—a computerized data handling system.

The working conditions of the instrument were set up, and 10 µL of each working standard was injected. The peak areas of each standard were recorded relative to the corresponding concentrations. The standards were run in the following order: 10 µg/mL, 20 µg/mL, 40 µg/mL, 60 µg/mL, and 80 µg/mL. A standard calibration curve for caffeine was prepared using a plot of peak areas versus standard concentrations. The samples were run in triplicate, and the mean concentration of each sample was obtained. The amount of caffeine in the original drink (sample) was calculated using the calibration curve.

The data were analyzed using Microsoft Excel. The concentration of caffeine in the original sample was obtained by extrapolation or using the equation of the line from the calibration curve. The data are presented in the tables and graphs.

Figure 1

Schematic Diagram of the High-Performance Liquid Chromatography (HPLC) System



Choice of the Method

Qualitative and quantitative analysis of caffeine levels was conducted using HPLC because the instrument was available, precise, accurate, and easy to operate. Additionally, caffeine standards were readily available. Different standards of caffeine were used to create a calibration curve. Subsequently, the samples were also processed, and their peak areas were integrated, as shown in Table 1.

Table 1

Peak Areas and Concentrations of Caffeine Standards

Concentrations (ppm)	Peak Area (microV*sec)
0	0
10	401612
20	828729
80	4235965

Figure 2

The Calibration Curve Illustrates the Relationship between the Concentration of Caffeine Standards and their Respective Peak Areas

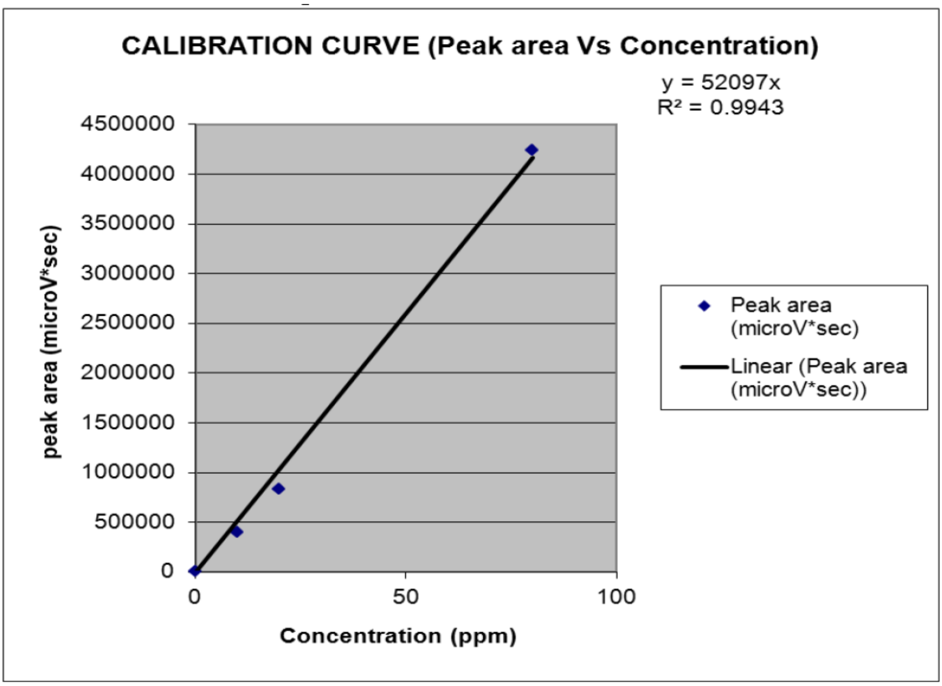


Table 2

Peak Areas of Caffeine in Various Brands of Cocoa and Coffee

Samples	Peak Area	Dilution Factor	Amount Weighed(g)
Cocoa Brand A	536118	1	2
Cocoa Brand B	274730	1	2
Cocoa Brand C	1982811	1	2
Cocoa Brand D	1659661	1	2
Coffee Brand A	1291361	2.5	2
Coffee Brand B	4440973	2.5	2
Coffee Brand C	17794832	2.5	2
Coffee Brand D	14733679	2.5	2
Coffee Brand E	5410661	2.5	2

Table 3

Concentrations of Caffeine in Various Brands of Cocoa and Coffee.

Samples	Concentration (ppm)	Dilution Factor	Amount Weighed (g)
Cocoa Brand A	10.2908 ppm	1	2
Cocoa Brand B	5.2734 ppm	1	2
Cocoa Brand C	38.06 ppm	1	2
Cocoa Brand D	31.8571 ppm	1	2
Coffee Brand A	24.7876 ppm	2.5	2
Coffee Brand B	85.2443 ppm	2.5	2
Coffee Brand C	341.5711 ppm	2.5	2
Coffee Brand D	282.8124 ppm	2.5	2
Coffee Brand E	103.8574 ppm	2.5	2

Table 4

Original Concentration of Caffeine in Various Brands of Cocoa and Coffee

Samples	Concentration (µg/g)
Cocoa Brand A	5.1454
Cocoa Brand B	2.6367
Cocoa Brand C	19.03
Cocoa Brand D	15.9285
Coffee Brand A	30.9845
Coffee Brand B	106.5556
Coffee Brand C	426.9639
Coffee Brand D	353.5155

Figure 4

Amount of Caffeine in Various Brands of Cocoa and Coffee

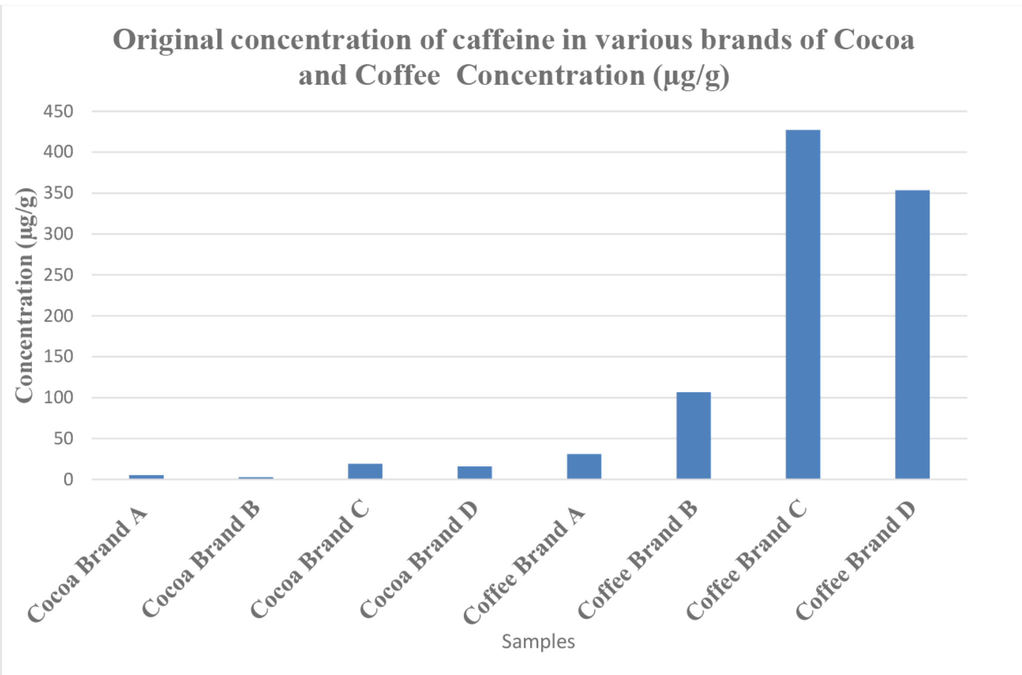


Figure 5

Amount of Caffeine in Various Brands of Cocoa

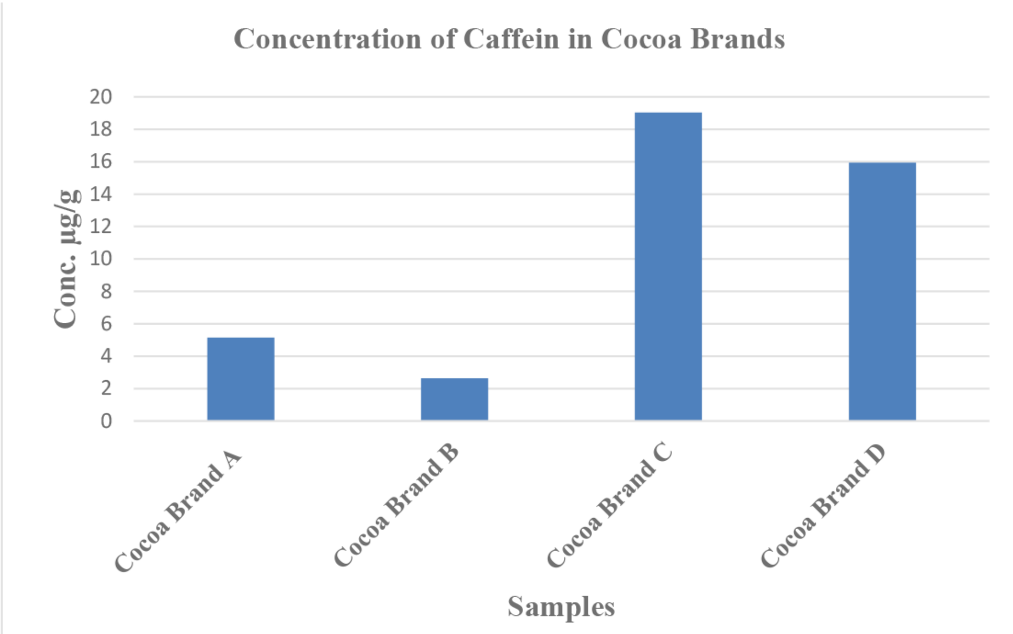
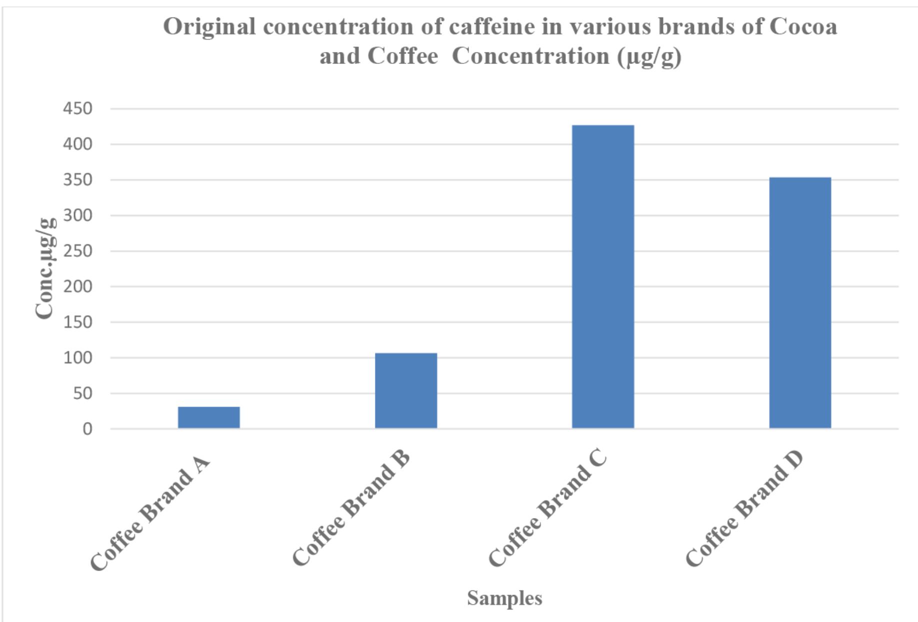


Figure 6

Amount of Caffeine in Various Brands of Coffee



Discussion

Cocoa and coffee contain various caffeine concentrations. From these results, it can be concluded that coffee has a higher concentration of caffeine than cocoa. Coffee Brand A recorded the lowest level of caffeine with 30.9845 µ g/g, while Coffee Brand C recorded the highest level of caffeine with 426.9639 µ g/g (Tables 3 & 4, Figures 5 & 6). Among the Cocoa brands, Cocoa Brand B recorded the lowest level of caffeine (2.6367 µg/g), while Cocoa Brand C recorded the highest level of caffeine at 19.03 µ g/g (Tables 3 & 4, Figure 4).

The results indicated varying concentrations of caffeine in cocoa and coffee products, with coffee generally exhibiting higher levels than cocoa. Specifically, Coffee Brand A displayed the lowest caffeine content among the coffee brands, measuring 30.9845 µg/g, whereas Coffee Brand C recorded the highest caffeine concentration at 426.9639 µg/g (Tables 3 & 4, Figures 5 & 6).

In contrast, among the cocoa brands, Cocoa Brand B had the lowest caffeine content, 2.6367 µg/g, while Cocoa Brand C had the highest concentration, 19.03 µg/g (Table 3, Figure 4). These findings highlight the significant differences in caffeine levels between coffee and cocoa products.

To bolster these observations, other studies have consistently reported similar trends, highlighting coffee's generally elevated caffeine levels compared with cocoa-based products. Such consistency across different studies enhances the robustness of the conclusion regarding higher caffeine concentration in coffee. To support this observation, numerous studies, including those conducted by Gonzales-Yépez et al. (2023) and Kalisz et al. (2023), consistently reported higher caffeine levels in coffee than in cocoa-based products. This collective body of research contributes to the robustness of the conclusion regarding the higher caffeine concentrations in coffee.

Conclusion

Caffeine is a potent and quick-acting drug that produces an effect similar to the stress response in humans. Caffeine affects each person differently, depending on individual circumstances such as weight, size, etc. It almost instantly affects your mind-body, which will continue to influence your state for 6-8 hours afterward. This study shows that coffee brands have higher caffeine levels than cocoa brands. Among the coffee brands, Coffee Brand C had the highest level of caffeine, while Coffee Brand A had the lowest level of caffeine. Among the Cocoa brands, the Cocoa Brand C recorded the highest level of caffeine, while Cocoa Brand A recorded the lowest level of caffeine. However, this research did not check the various preparation methods of coffee and cocoa to compare their concentrations in the cup; therefore, further research can be undertaken on this topic. This study provides a baseline for further research on caffeine levels in various beverages. The study strongly recommends the following:

1. Reduce daily coffee consumption to avoid potential health issues related to excessive caffeine intake.
2. Consume cocoa instead of coffee, as it contains less caffeine per serving, especially for those who are not regular caffeine consumers.
3. Limit the average caffeine intake from beverages such as coffee, cocoa, and tea to less than 200-400 mg per day.
4. Opt for processed coffee over unprocessed coffee, as the latter contains higher levels of caffeine.

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