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The Impact of Bean Type and Brewing Technique on Caffeine Content in Coffee Brews

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ABSTRACT

Coffee is the world's second most consumed beverage, and its popularity continues to rise. Made from dried and brewed beans, moderate coffee consumption offers various health benefits, including migraine relief, stress reduction, and an increase in antioxidants. However, understanding the caffeine content in locally available coffee drinks is crucial for consumer health and well-being. Excessive consumption can have adverse effects, such as anxiety, insomnia, digestive problems, and mental health issues. This study compared the caffeine content of hot Americano coffees made from Arabica and Liberica beans, sourced from local coffee shops in Kuching, Sarawak. Six samples were analyzed, with three brewed from Arabica beans (originating from Brazil, Costa Rica, and Indonesia) and three from Liberica beans cultivated in Sarawak. Liquid-liquid extraction using chloroform and Ultraviolet spectroscopy were employed for the analysis. The results showed that Arabica beans from Brazil had the highest caffeine concentration (948.506 ± 7.836 ppm), while Sarawak's Liberica beans had the lowest (579.595 ± 0.092 ppm). In order to study the effect of brewing techniques, brews prepared using an espresso machine and through the pour-over (V60) technique was compared for their caffeine concentration. The findings show the pour-over method yielded higher caffeine content for both Arabica and Liberica beans. This study highlights the influence of coffee bean types and origins, as well as brewing techniques on coffee's caffeine, offering valuable insights for coffee consumers and the local industry.

Keywords: Coffee, caffeine content, Arabica bean, Liberica bean, UV-visible spectrophotometer

INTRODUCTION

Coffee consumption has become a significant part of daily life globally and is especially popular in Malaysia, where both international and local coffee cultures thrive [1, 2]. Coffee, the second-most consumed beverage worldwide, has more than 100 species, with Arabica and Robusta being the most common beans utilized in the coffee industry [3]. Conversely, Liberica beans is a less common species of coffee. However, as global climate change, Liberica emerges as a resilient option as this species possesses adaptability to shifting climate patterns [4]. Arabica coffee is originated in the high-altitude forests of Ethiopia and is highly regarded by its exceptional quality and delightful flavour [5]. Liberica beans are much larger than arabica and robusta beans, and they are distinguished by their unique jackfruit-like aroma [6]. In recent years, the national government and regional agricultural organizations in Sarawak have made intensive efforts to promote the cultivation of Liberica coffee, though there are still challenges that need to be addressed [4].

In Malaysia, coffee culture has evolved, with local coffee shops (Kopitiam) and international franchises such as Starbucks and Coffee Bean catering to an increasing demand for quality coffee products. Despite this, there is limited transparency regarding the nutritional content and active ingredients, such as caffeine, in the beverages offered by local coffee shops. Excessive caffeine consumption is linked to adverse health effects, including

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anxiety, insomnia, digestive disorders, and mental health issues [7, 8]. Therefore, understanding the caffeine content in various coffee drinks is essential for consumer awareness and health considerations. However, more comprehensive studies are needed to focus on the caffeine content in locally brewed coffee drinks and the influence of different brewing techniques on this content.

This study aims to determine the caffeine content of various local coffee drinks sold in the local cafes and to examine how different bean types and origins, as well as brewing techniques affect the caffeine concentration. Six coffee samples were purchased from local coffee shops, and liquid-liquid extraction was employed using chloroform as the solvent to isolate the caffeine from the coffee samples. The extracts were subsequently analysed using Ultraviolet-Visible spectroscopy to quantify caffeine concentration. The findings from this will provide essential data for quality control, ensuring products meet demand and comply with health regulations, which consequently can enhance the reputation of coffee businesses.

METHODOLOGY

Materials

Caffeine standard, Chloroform. All chemicals were analytical-reagent grade. All solutions were prepared using deionized water.

Sample Collection

Hot Americano coffee samples were obtained from different coffee shops located in Kuching, Sarawak. The brewing technique used as well as the type and the origin of the coffee beans were recorded.

Extraction of Caffeine

Caffeine was extracted from the coffee samples according to the method by [9] with some modifications. Approximately 5.0 ml freshly brewed coffee sample was inserted in a separating funnel, followed by the addition of 0.50 mL of sodium hydroxide and 20 mL chloroform. The funnel was inverted three times and allowed to stratify for 5 minutes. The chloroform layer was removed in a clean 100 mL volumetric flask. The extraction was repeated twice more, each with a 20 mL chloroform addition. The combined extract was dissolved with chloroform up to the calibration mark. Each coffee samples were extracted according to the same procedure and prepared in triplicates.

Spectrophotometric determination of caffeine content

Quantitative analysis of caffeine was performed using a UV/Vis Spectrometer. The λ max was determined by scanning the standard caffeine solution from 190 - 400 nm and the obtained results gave an absorption spectrum, which was characterized by a single intensive absorption band located in the UV range at λ max at = 276 nm. The standard linear calibration curve was run to obtain the linear range of sample analysis, the correlation factor was with accepted value = 0.9923 and the standard calibration curve was linear with equation $y = 0.0609x + 0.1618$. The quantitative amount of caffeine in samples (ppm) was then determined using the standard calibration curve.

RESULTS AND DISCUSSION

Caffeine Content

The caffeine content in six coffee samples brewed from different coffee bean types and different origins is presented in Table 1. Based on the results, the highest caffeine concentration (948.506 ± 7.836 ppm) was found in a sample labeled as A2, which is coffee brewed from Arabica beans that originated from Brazil. In contrast, sample labeled as L1, coffee brewed from Sarawak's Liberica beans was found to contain the lowest caffeine content (579.595 ± 0.092 ppm). The finding of this analysis supports a study by [10], which found that Arabica beans have a greater caffeine level (1.06 g/100g) compared to Liberica beans (0.86 g/100g).

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Table 1 The caffeine content in coffee samples.

Sample	Bean type	Origin	Caffeine content (ppm)
A1	Arabica	Costa Rica	773.684 ± 3.907
A2		Brazil	948.506 ± 7.836
A3		Indonesia	751.571 ± 3.677
L1	Liberica	Sarawak	579.595 ± 0.092
L2		Sarawak	606.086 ± 1.092
L3		Sarawak	625.025 ± 2.343

For samples brewed from Arabica beans, a variation in the caffeine content can be observed based on the bean's geographical origin. A study conducted by [11] shows that Arabica beans grown in Kenya and Ethiopia have been discovered to have less caffeine than Arabica beans cultivated in Brazil. The difference in caffeine content of coffee beans with different origins is due to the overall amount of chemicals in the beans, which is also influenced by the surroundings, such as light and altitude above sea level. For instance, in a study by [12], the Arabica bean cultivated at an elevation of ≥1200 m above sea level has a greater caffeine concentration (13.39% to 12.35 g/kg of beans) compared to coffee bean grown at an elevation of less than 1000 m above sea level.

Effect of Different Brewing Techniques

Research has demonstrated that the brewing technique of coffee bean has an impact on its characteristics, in which the parameters involved significantly influence the extraction kinetics of the various chemical compounds found in the roasted bean [13]. In order to assess how the brewing technique affected the composition of the brew, a pair of coffee drinks from each bean were prepared using different techniques; one brewed with an espresso machine and another using the pour-over (V60) technique. The samples then were analysed for the amount of caffeine using an ultraviolet/visible spectrophotometer. Figure 1 provides a summary of the findings.

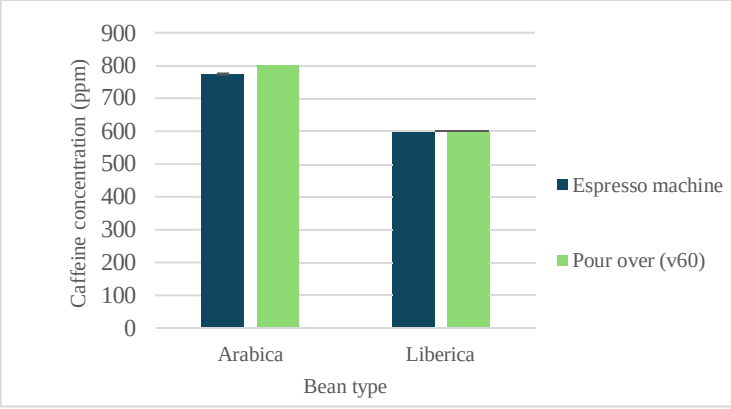

Fig. 1 Comparison of caffeine concentration by different brewing techniques.

After examining the caffeine content of four particular coffee drinks prepared using two separate techniques, it is evident that the outcomes vary. A higher quantity of caffeine was found in both coffee beans when brewed using the pour-over method. The Arabica bean had a greater caffeine concentration at 819.004 ± 9.360 ppm, whereas the Liberica bean had a maximum of 625.025 ± 2.898 ppm. Falls under the infusion category of extraction, pour over (V60) achieves the highest caffeine extraction rate because hot water can evenly pour over the ground coffee at a specific temperature, allowing for the rapid release of dissolved components within the first 2 minutes of extraction [13]. In contrast, an espresso machine employs a driving force (high pressure) to rapidly push hot water through a compact bed of coffee grounds [14]. A study conducted by [15] also shows that coffee brews using the V60 technique exhibit the highest caffeine content when compared to Tubruk and cold brewing methods.

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CONCLUSIONS

The findings of this study show that the bean types and origins, as well as brewing techniques, have a significant impact on the caffeine concentration of coffee brews. Generally, samples brewed from Arabica beans have greater caffeine content than those with Liberica beans. Additionally, the variation of geographical origins of the Arabica beans used in this study supports that the cultivation environment of the beans could influence the caffeine level in coffee. Further investigation on the impact of brewing techniques demonstrates that the pour-over (V60) method produced a higher quantity of caffeine for both Arabica and Liberica beans, compared to espresso machine brews. Liberica coffee presents an interesting subject for future research as Sarawak is an important region for the cultivation of Liberica beans. Conducting in-depth studies on Liberica beans could reveal the unique characteristics of these beans and contribute to a greater understanding of their potential in the coffee market.

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