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Review Article: Analysis Caffeine in Powder Coffee Using Spectrophotometry UV-VIS Method

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Abstract
Introduction: *Caffeine is made by extraction from roasted and ground coffee by dichloromethane after being heated in deionized water mixed with magnesium oxide. The extract was purified, dried and bottled in a bottle of dark glass. A stratified random selection was applied to select a number of vials for the study of homogeneity and stability, which revealed that the prepared reference material was homogeneous and fairly stable.* ***Objective:*** *This study aims to determine the level of caffeine levels in ground coffee. The quantification of the % purity of caffeine was performed using a calibrated UV/visible UV/visible spectrophotometer and high-performance liquid chromatography calibrated by the diode-array detection method.* ***Method:*** *This study uses literature review, from several articles published in literature through PubMed, Science Direct, Researchgate, publons and Google Scholar with articles published from 2012 to 2022.* ***Result and Discussion:*** *The results obtained from both methods combined to drive the certified value and uncertainty regarding the certified value of the purity of the reference material were found to be 99.86% and the associated uncertainty was ±0.65%, which makes the candidate reference material a very useful calibran in the chemical analysis of food and medicine.* ***Conclusion:*** *It can be concluded that the caffeine levels contained in robusta and arabica coffee beans with varying soaking duration of 3 days, 5 days, and 7 days there are differences in caffeine levels*
Keywords: *Caffeine; UV-VIS spectrophotometry; Powder Coffee;*

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Introduction

Caffeine is a type of alkaloid that is widely found in coffee beans, tea leaves, and chocolate beans. Caffeine belongs to the group of compounds "methylxantin" (Fajriana & Fajriati, 2018). Methylxantin is a naturally formed compound and belongs to the xanthine derivative which is a class of alkaloid compounds (Safitri et al., 2020). Other members of the methylxantin group are theophylline contained in tea, and theobromin contained in chocolate. Coffee contains an active compound that is pharmacologically a derivative of methylxanthine, namely caffeine.

Differences in the influence of these products may be possible in the differences in the compounds they contain. Caffeine has clinically beneficial pharmacological effects, such as stimulating central nervous milking, relaxation of smooth muscles especially bronchial smooth muscles and stimulation of the heart muscle (Maramis, 2013). But excess caffeine in the body can also have negative effects and is often associated with health risk factors such as increased blood pressure, cholesterol and increased gastritis (Bistara & Kartini, 2018)

Caffeine can accelerate the formation of stomach acid in the body, where the stomach produces excess gas, causing flatulence. Caffeine crystals in water in the form of needles - silk luminous needles. When it contains no water, caffeine melts at 234°C to 239°C and sublimates at lower temperatures. Caffeine is easily soluble in hot water and in chloroform, but slightly soluble in cold water, alcohol and some other organic solvents.

Method

The method used in this study was to search a database taken from several scientific articles through PubMed, Science Direct, Researchgate, pubons and Google Scholar. Articles published from the range of 2012 to 2022 using keywords, between lalin: Caffeine, Spectrophotometry UV-VIS analysis was carried out by taking data from coffee plants, namely beans and others. By analyzing UV-VIS spectrophotometry from several research results which are then summarized.

Taxonomy

In the systematics (plant taxonomy) of coffee plants, it is classified as follows:

Kingdom : Plantae
Divided : Tracheophyta
Class : Magnoliopsida
Ordo : Gentinales
Family : Rubiaceae
Genus : Coffe L.
Spesies : Coffe arabica L, Coffea benghalensis B, Coffea canephora pierre, Coffea stenophyla G. Don, dan Coffea liberica W. Bull.

Coffee can be traced to a genus of plants known as Coffea. In this genus there are more than 500 sub-genera and 6,000 species of tropical shrub trees. The genus was first

described in the 18th century by a Swedish botanist, Carolus Linnealus, who described Coffea arabicl in his Species Plantarum book in 1753.

The hli of plants find it difficult to do the proper classification of these plants. This is considering coffee plants can cover everything from small shrubs to tall trees, leaves measuring 1 to 40 cm with a variety of colors, from purple, yellow to predominantly dark green.

The root system of coffee plants is a non-lying tap, relatively shallow, more than 90% of the root weight there is a 0-30 cm layer of soil. The stem of the coffee plant is a woody plant with a grayish-white color and upright upwards. The stem consists of 2 kinds of buds, namely series buds (reproductive buds) that grow in the same direction as the place of origin and legitim buds that only grow once with the direction of growth forming a real angle in the original place. The fruit consists of pulp and seeds. The flesh of the fruit consists of 3 parts, namely the outer skin layer (exokarp), the flesh layer (mesokarp), and the horn skin layer (endocarp) which is thin but hard. Coffee fruits can produce two grains of beans but there are also those that do not produce seeds producing only one grain. Coffee beans consist of bean shells and institutions. Morphologically, coffee beans are ovoid with a hard texture and dirty (Najiyati and Danarti, 2012).

Botanical Description

Coffee (coffea sp) is one of the tree-shaped plant species that belongs to the family Rubiaceae and the genus Coffea.This plant grows upright, branched, and beranting. Coffee has a branching system that is different from other plants. The plant has several types of branches whose properties and functions are somewhat different. Agricultural R&D Agency

Coffee is a shrub plant with a height of between 2 - 4 meters. Coffee has a shallow root system, more than 90% of the roots are in the soil layer at a depth of less than 30 cm. Therefore, coffee plants are very sensitive to the content of organic matter and seasonal changes. The stem of the coffee plant has two types of branching, namely branches that grow upright (orthotroph) and branches that grow horizontally. The function of the plagiotrop branch as a flower producer, while the orthotropic branch grows rapidly with relatively long internodes.

Coffee has ovate-shaped leaves with a pointed tip. The leaves in orthotropes are arranged intermittently, while in plagiotropes the leaves are arranged horizontally and not criss-crossed. Rara-average coffee leaf length measures 20 - 30 cm with a width of about 10 - 16 cm and leaf veins sink so that the leaf surface looks squiggly.

After pollination and fruiting, the fruit ovule will develop into a fruit. The fruit will continue to grow and be ready to be harvested after nine months to a year. The coffee plant will only produce fruit once a year and will be harvested from March to September. Coffee fruit is of the drupa type with an ovoid shape, consisting of 4 layers, namely the outer skin (exocarp), fruit flesh (mesocarp), horn skin (parchment), and seeds. The skin of the coffee fruit is very thin and contains chlorophyll and other dyes so that when young the coffee beans are green and if they are too old they turn red.

Coffee beans contain protein, aromatic oils, and organic acids. In general, coffee beans contain water (48%), dry matter (50 –52%), carbohydrates (60%), oils (13%), proteins (13%), non-volatile acids (8%), ash (4%), trigonelin (1%) and caffeine (arabica 1.0%; robusta 2.0%)

Result and Discussion

1. Result

In the research conducted by (F. Albak & A.R. Tekin., 2015) with the title "Variation of total aroma and polyphenol content of dark chocolate during three phases of concing" obtained the result that acetic acid is an important compound that has a significant influence on the aroma of chocolate, this is because it gives an unwanted taste, such as the smell of vinegar. Acetic acid is produced from the oxidation of aldehydes and alcohols released from ether by a mechanism during a long conching process (Albak & Tekin, 2016)

In the study conducted by (Al. B. Shehalta et all., 2016) with the title "Certification of caffeine reference material purity by ultraviolet/visible spectrophotometry and high-perfomance liquid chromltography with diode-alrraly detection as two independent alnalytical methods" obtained results namely to ensure extraction from roasted coffee caffeine samples purchased from Alfa Alesar and caffeine samples extracted using HPLC systems and UV-VIS spectrophotometers. The HPLC chromatography generated from both samples displayed at two absorption peaks appeared at 273 ± 1 nm. It guarantees the extraction of caffeine from roasted coffee (Shehata et al., 2016)

In a study conducted by Rialital Kesia Maramis, 2013 with the title "Analysis of clfein in ground coffee in manado city using UV-VIS spectrophotometry" obtained the results of increasing caffeine levels influenced by the weight of ground coffee used. The addition of calcium carbonate causes high caffeine levels in the separation between caffeine and other compounds, so that the caffeine produced in free bases is increasing (Maramis, 2013)

In a study conducted by (Nur has ani fajriana, 2018) with the title "Analysis of caffeine levels of arabica coffee (coffea arabica L) on sangria temperature variations in ultra violet spectrophottry" obtained the results of caffeine levels influenced by roasting temperature. If the roasting temperature continues to rise, the caffeine level in coffee will decrease. This is because in the roasting process a small part of caffeine will evaporate and other components will be formed, namely aldehydes, furfurals, ketones, alcohols, esters, formic acid, and acetic acid which have volatile properties. The higher the sangria temperature, the easier caffeine will evaporate and the levels will decrease (Fajriana & Fajriati, 2018)

In a study conducted by (Fathia Rizqi Aprilia, 2018) with the title "Analysis of caffeine content in traditional gayo coffee and Lombok coffee using HPLC and UV-VIS Spectrophotometry" obtained results that the analysis of caffeine levels using UV/VIS spectroscopy showed higher levels compared to analysis using HPLC. However, this does

not mean that analysis using UV / Vis is much more sensitive than HPLC, because the two instruments have different working principles (Aprilia et al., 2018)

In the research conducted by (Hari Susanti, 2019) with the title "Comparison of UV and HPLC Spectrophotometry Methods on the Determination of Caffeine Levels in Coffee" obtained results that the HPLC method and UV spectrophotometry have good linearity and meet the requirements. The HPLC method has better sensitivity than UV spectrophotometry. This can be seen from the lower LOD and LOQ values. Spectrophotometric methods have qualified precision and accuracy values and are better than HPLC. From the overall validation results, in this study more recommended UV spectrophotometry method. In addition to being easier, cheaper, it turns out to have better validation parameters than HPLC, especially in method accuracy (Susanti et al., 2019)

In the study conducted by (Iswandi, 2022) with the title "The effect of immersion on caffeine levels in coffee beans in the city of Surakarta on UV-VIS spectrophotometry" obtained the results that the caffeine levels contained in robusta and arabica coffee beans with varying soaking duration of 3 days, 5 days, and 7 days there were differences in caffeine levels, but for the types of coffee both Robusta and Arabica there was no difference in extracted caffeine levels (Iswandi, 2022)

In the research conducted by (Ade Irma Mayani, 2022) with the title "Isolation and identification of caffeine from coffee with UV-VIS and FTIR spectrophotometry instruments" obtained the results that caffeine can be purified by microsublimation. In this micro-sublimation process, it produces yellowish-white crystals. The weighed beaker glass is reduced by the beaker glass containing crystals. The yield is 0.03grams and the yield of caffeine in coffee is 0.075%. After that, the obtained caffeine crystals are scraped off using a spatula. Then the crystals were tested using UV-VIS Spectrophotometers and FTIR (Maylani et al., n.d.)

In a study conducted by (Isnindar, 2016) with the title "Analysis of caffeine content in raw coffee fruit extract from Merapi plantation in the special region of Yogyakarta using UV-VIS spectrophotometry" obtained the results that the caffeine content in raw coffee fruits using the UV-VIS spectrophotometry method. The ultra violet spectra of raw coffee fruit chloroform extract shows the presence of maximum absorbance at a wavelength (λ) of 273 nm. The presence of a long chromophore group resulted in fluorescent chloroform extract at initial detection using UV 254 (Isnindar, 2016)

In a study conducted by (Aryanu Fahmi Arwangga, 2016) with the title "Analysis of caffeine content in coffee in sesaot narmada village using UV-VIS spectrophotometry" it was found that the caffeine content in coffee in Sesaot Village, Narmada District, West Lombok, namely raw coffee was 1.28 ± 0.82% with a flow content of 3%, pure coffee of 1.63 ± 0.13% with a flow content of 1%, and blended coffee of 0.87 ± 0.01% with a flow content of 1% (Arwangga et al., 2016)

In the research conducted by (Balqis Fitri Ayuni, 2022) with the title "Validation of caffeine analysis methods in coffee lattes with UV VIS spectrophotometry" it was found that method validation is a stage carried out through laboratory studies that the procedure criteria meet the requirements for analytical applications. The validation tests

performed showed results that were linear (r 2 = 0.9927), precise (RSD = 0.853%), accurate (Recovery = 106.263%), and specific because the maximum wavelength of the sample ± 2 nm of the maximum wavelength of the raw solution (273 nm) (Ayuni, 2022)

In the study conducted by (Nur Patria Tjahjani, 2021) with the title "Analysis of differences in caffeine levels in black ground coffee and instant white ground coffee spectrophotometry UV-VIS" obtained results that caffeine levels were obtained in samples of black ground coffee and instant white ground coffee, namely: H1 4.8 mg / g; H2 3.65 mg/g; H3 4.85 mg/g; H4 3.95 mg/g; H5 3.85 mg/g; P1 9.85 mg/g; P2 8.8 mg/g; P3 9.6 mg/g; P4 7.4 mg/g; P5 6.45 mg/g. The test results stated that there was a significant difference in caffeine levels in black ground coffee and instant white ground coffee (Tjahjani et al., 2021)

In a study conducted by (Yoman Suwiyarsa, 2018) with the title "Analysis of caffeine levels in local ground coffee circulating in the hammer city" found that caffeine levels in six samples of local ground coffee in 1 consecutive gram had caffeine levels of 8,348; 20,619; 16,032; 26,353; 12,993 and 17,293 mg. if made in % w/w then every 1gram of ground coffee 6 samples contains a successive 0.83; 2,06; 1,60; 2,63; 1.29 and 1.72% caffeine levels (Suwiyarsa et al., 2018)

In a study conducted by (Andi Iham Latunra, 2021) with the title "Analysis of coffee caffeine content (Coffea Arabica) at different maturity levels using UV-VIS sprectophotometry" obtained results that the highest caffeine levels were found in the maturity level of yellow-orange half-old coffee and the lowest caffeine content was found in arabica coffee with a green young maturity level (Latunra et al., 2021)

In a study conducted by (Al. Dankowska et all., 2017) with the title "Quantification of Coffea arabica and Coffea canephora var. canephora). robusta concentration in blends by means of synchronous fluorescence and UV-VIS spectroscopies" obtained the result that "UV-VIS absorption spectrum of original Arabica flow extract and robusta coffee samples and their mixtures in the range of 190–700 nm. The intensity of the UV-VIS spectrum of different coffee species depends, among other things, on the content of caffeine, chlorogenic acid, and trigonelin molecules. Caffeine shows maximum absorption at around 275 nm, so the spectrum in this region is strongly related to the chromophore absorption of caffeine, but the influence of other compounds, eg. Other methyxanthines, on this spectrum can't be excluded (Dankowska et al., 2017)

In the study conducted by (Nuzu Valianti Dewi, 2017) with the title "Differences in caffeine levels in seed extract, peel, fruit and coffee leaves (Coffea Arabica L) with the UV-VIS sprectophotometry method" obtained results that samples of seed extract with coffee fruit peel there was no difference in caffeine levels, while in samples of bean extract with coffee leaves and fruit peel extract with coffee leaves showed a difference in caffeine levels (Dewi et al., 2017)

2. Discussion

Coffee is one of the most popular drinks in Indonesia. Coffee can be enjoyed not only from the elderly, but has become one of the drinks favored by young people

(Maramis. R. K., et.2013) (Maramis, 2013). Coffee (Coffea sp) has long been known by the public since centuries ago, coffee is known as a beverage ingredient commodity that is most familiar to people of all walks of life. Coffee can be served into a delicious drink in a variety of settings. In addition to its attractive taste and aroma, coffee can also reduce the risk of cancer, diabetes, gallstones, and various cardiovascular diseases in caffeine-containing coffee (Tjahjani et al., 2021)

Caffeine is a type of alkaloid contained in coffee, tea and chocolate. When consumed, caffeine can have an effect on the body, which can stimulate the central nervous system, and the heart muscle (Aprilia et al., 2018). The safe limit of caffeine consumption that enters the body per day is 100-150 mg. In a cup of coffee it usually contains 50 mg of caffeine, so it is recommended to drink coffee no more than 3 cups of coffee a day (Tjay & Rahardja, 2015). Caffeine in coffee has pharmacological effects clinically, including being able to stimulate the nervous system, relax smooth muscles, especially in the bronchi muscles and stimulate the heart muscle (izzatina Rahmawati & Rejeki, 2021)

The content in caffeine in coffee is different, Fatoni (2015) analyzed quantially and quantitatively the caffeine levels of local ground coffee circulating in Palembang using the UV-VIS spectrophotometry method with the results of research on caffeine levels from 10 samples of local ground coffee brands still within reasonable limits or not exceeding the usual dose, namely 300-600 mg. (Arwangga et al., 2016) analyzed the caffeine content in coffee in Sesaot Narmada village using the UV-VIS spectrophotometry method with the results of research on caffeine levels in raw coffee of 1.28 ± 0.82% with a flow content of 3%, pure coffee of 1.63 ± 0.13% with a flow content of 1%, and mixed coffee of 0.87 ± 0.01% with a flow content of 1%. Based on SNI 01-3542-2004 the caffeine content in ground coffee is 0.45-2.00% w/w. Therefore, it is necessary to have information to recognize the caffeine content contained in local ground coffee (Maskar & Faisal, 2022)

Several studies have tested caffeine levels in ground coffee using the UV-VIS Spectrophotometry method (Arwangga et al., 2016). The results of the study provide different data, this is because the caffeine levels in coffee can be influenced by the geographical location and type of coffee plant.

The determination of caffeine levels in some beverage products and not beverages, has been widely carried out by previous researchers with various methods, such as the determination of caffeine levels in kola type soft drinks by high-acting liquid chromatography (KCKT) (Levital, et al., 2004).

Conclusion

Based on the results of experiments that have been carried out, it can be concluded that the caffeine levels contained in robusta and arabica coffee beans with varying soaking durations of 3 days, 5 days, and 7 days there are differences in caffeine levels, but for the types of Robusta and Arabica reverse coffee there is no difference in extracted caffeine levels.

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