*Research Article*

# Chemical Properties of Tea Leaves and Coffee Bean Products

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**Abstract:** *Both coffee and tea have caffeine, but the rest of their chemical makeup is quite different. Green tea has several important natural compounds such as polyphenols, caffeine, amino acids (especially theanine) and some aromatic substances. These compounds are linked to health benefits like fighting cell damage (antioxidant effects), reducing inflammation, lowering cancer risk, protecting the brain and helping to control blood sugar. One group of compounds called catechins, especially one called EGCG is mainly responsible for many of green tea's positive effects on health. On the other hand, Arabica coffee (Coffea arabica) is the most commonly consumed type of coffee and is an important part of many cultures. In places like Saudi Arabia, it plays a key role in traditional hospitality. Coffee beans have many natural compounds, including caffeine, catechins and phenolic compounds (mainly chlorogenic acid and its derivatives). These substances are known for their strong antioxidant effects and may help reduce inflammation, protect the heart, and stimulate the brain. Coffee's unique taste and smell mostly come from its aromatic compounds, many of which are created during roasting. Roasting also affects how much of these healthy compounds stay in the coffee.*

*Keywords: chemical; tea leaves; coffee bean.*



## 1. INTRODUCTION

Tea and coffee are two of the most popular drinks in the world, known for their pleasant smell, taste, and energizing effects (Baite, Mandal, & Purkait, 2024). People from many cultures and backgrounds enjoy them daily, and they have been part of human diets and social customs for a long time (Yohannis et al., 2024). As observed by LIczbiński & Bukowska (2022), their widespread use is not just because of how they taste or smell, but also because of the many natural chemicals they contain that can affect the body in useful ways. Both drinks have health-related benefits thanks to important active ingredients like caffeine, antioxidants, and plant compounds called polyphenols.

According to Vable (2024), coffee and tea started in different places and at different times. Tea has a much older history, first mentioned around 1,000 BCE in what is now southwestern China. Coffee appeared later, with its earliest records from around 850 CE in eastern Africa, near today's Ethiopia. Both drinks became popular early on because they helped people to stay awake during long religious ceremonies. Buddhist monks helped spread tea from China to other parts of Asia, while Sufi priests helped make coffee well-known in what is now Yemen. Interestingly, both drinks were introduced to Western countries at about the same time, in the 1650s.

Drinking green tea and Arabica coffee has become a common habit around the world because of their pleasant taste and proven health benefits (Stoikidou and Koidis, 2023). However, there is limited research that directly compares their chemical compositions, especially the bioactive compounds that can affect health. While many studies have looked at the chemical properties of each drink separately, few have compared them side by side. Most research focuses on just one type of beverage and does not analyze the differences that can influence taste and health benefits. This research aims to solve the problem of lack of full comprehension on how the different chemical properties in green tea and Arabica coffee affect their health benefits, taste and consumer preferences. Understanding these differences can help consumers make better choices based on their health goals and allow healthcare providers to recommend drinks that suit a person's needs. The results of this research can also support future studies in nutrition and help improve the development of healthy beverages.

This research will be useful for several important groups, including consumers, health professionals and the food and beverage industry. For consumers, the study offers helpful information about the chemical properties of green tea and Arabica coffee. This can help people choose drinks based on their health goals such as improving heart health or brain function.Furthermore, health professionals, namely dietitians and nutritionists can also use these findings to recommend beverages that suit their patients' individual health needs. In addition, the food and beverage industry can benefit by understanding the chemical differences between green tea and Arabica coffee. As more people look for healthy drink options, companies can use this knowledge to create new products, improve current recipes and adjust their marketing to meet the demand for functional beverages. Lastly, this research fills a gap in current studies by offering a direct comparison of the two drinks, something that has not been fully explored before.

## 2. METHOD & MATERIAL

Green tea and Arabica coffee were chosen as the main samples because they are widely consumed and known for their health benefits . The green tea samples will consist specifically of Sencha loose-leaf green tea, a Japanese variety known for its high content of catechins, particularly EGCG, as well as caffeine and polyphenols. Sencha is minimally processed through steaming, which helps preserve its antioxidant compounds, making it suitable for chemical and antioxidant analysis. For Arabica coffee, light-roasted ground coffee will be used, as it retains a higher level of chlorogenic acid (CGA) and reflects a commonly consumed form of the coffee bean that balances both flavor and bioactive compound content. All samples will be sourced from reliable suppliers that provide clear labeling and quality assurance to make sure the authenticity and consistency. Choosing these specific types of samples which are minimally processed allows for an accurate comparison of their chemical compositions, antioxidant properties and flavor-related compounds especially in forms that people drink every day.

## 3. FINDINGS

### *3.1 UV-Visible Spectroscopy*

In this study, the expected results for analyzing caffeine in sencha loose-leaf green tea using UV-Vis is based on caffeine's specific absorbance pattern. Pure caffeine shows a clear absorption in the UV range between 243 nm and 302 nm. Its peak absorbance ($\lambda_{max}$) changes slightly depending on the solvent, it appears at 276 nm in dichloromethane and chloroform along with 272.8 nm in water. The shape of the absorbance curve is consistent and helps in identifying caffeine. Caffeine solutions also follow the Beer-Lambert law, which means absorbance increases in direct proportion to concentration. This relationship makes it possible to calculate caffeine amounts accurately.

However, direct UV-Vis analysis of tea is difficult because other compounds in the tea such as pigments and polyphenols also absorb UV light. These interfering signals are known as matrix effects. To avoid this, caffeine is first extracted by dissolving the tea leaves in hot water, then separating it using dichloromethane through liquid-liquid extraction. This process is repeated about four times to improve caffeine removal. Most caffeine is removed in the first extraction, with less in the following rounds. After extraction, the UV-Vis spectrum of the solution should match the spectrum of pure caffeine, confirming a successful separation. If tea is blended with other ingredients like cinnamon, the spectrum may shift slightly, but in plain sencha tea, the typical caffeine peak should remain clear and within the expected range.

Based on pure catechins such as EGCG, ECG, EGC and EC show clear UV absorption patterns, mostly between 246 nm and 378 nm, depending on the type of catechin and the solvent. Each catechin has a specific peak absorbance (λmax). For example, EGCG typically shows a λmax at around 273.6 nm while ECG peaks near 276.8 nm in aqueous solutions. In water, the peak absorbance values for catechins generally fall between 269 and 279 nm. The Beer-Lambert law applies well to these compounds, meaning that absorbance increases proportionally with concentration. As a result, calibration graphs show strong linearity with very high correlation values close to 1. This makes UV-Vis a reliable tool for measuring catechin levels even at low concentrations.

However, direct analysis of tea leaves is not effective because other components like caffeine and pigments interfere with the readings. Therefore, an extraction process is needed. The tea leaves are first dissolved in water and then washed several times with chloroform to remove these non-polar compounds. After washing, the chloroform phase becomes spectrally flat, showing that the unwanted materials have been removed. The remaining water phase, which contains the catechins, is then analyzed. The UV-Vis spectrum of this extract should closely match the spectrum of pure catechins, confirming successful extraction. Expected results for sencha loose-leaf green tea should show a peak absorbance around 270-273 nm. The total catechin content can be calculated using Beer's law. Based on past studies, catechin content may range from around 7% to 17% by dry weight, with results showing high accuracy and low variability.

*3.2 Fourier Transform Spectroscopy (FTIR)*

Based on FT-IR analysis, pure caffeine in chloroform shows clear and characteristic absorption bands, especially two strong carbonyl bands around 1704.8 $cm^{-1}$and 1658.5 $cm^{-1}$.Other important bands appear at 1554.4, 1415.5 and 1361 $cm^{-1}$also the full spectrum ranges from 4000 to 600 $cm^{-1}$. When caffeine is extracted from tea using chloroform, the FT-IR spectrum of the extract closely matches that of pure caffeine, confirming successful isolation. However, some tea extracts, including green tea like sencha, may show a slight overlapping peak around 1730 $cm^{-1}$, likely caused by other substances in the tea. Despite this, the main caffeine bands, especially the one at 1658.5 $cm^{-1}$, remain visible and reliable for analysis. For quantification, the band at 1658.5 is preferred because it is less affected by the $cm^{-1}$overlapping peak at 1730. A calibration curve using this band, with baseline correction at $cm^{-1}$1800 , shows excellent linearity ($R^2$ = 0.9993), and the method has good sensitivity (0.2142 $cm^{-1}$absorbance units per mg/mL caffeine). The limits of detection (LOD) and quantification (LOQ) are 1 mg/L and 3.4 mg/L, respectively which equals about 0.002 - 0.007% in tea leaves. For sencha green tea, the expected caffeine content using this FT-IR method is around 2.70 ± 0.02% (w/w), based on three measurements. The method also performs well in terms of accuracy and precision, showing recovery rates between 97 - 98% and low variation (RSD around 0.1%).

Based on the FT-IR analysis of sencha loose-leaf green tea, several peaks are expected to confirm the presence of chemical compounds linked to antioxidant activity, such as polyphenols and flavonoids. The most important bands include a strong peak around 1634 $cm{-1}$ , which is related to the stretching vibrations of C=C and C=O bonds found in antioxidant $cm{-1}$compounds like catechins, gallic acid and L-theanine. Another key feature is a broad band at around 3284 $cm{-1}$ , which represents O-H stretching from the hydroxyl groups found in $cm{-1}$polyphenols and flavonoids. These two bands are strong indicators that the tea extract contains antioxidant-rich compounds.

Additional peaks may also appear in the FT-IR spectrum, supporting the presence of other bioactive or naturally occurring compounds in green tea. These include a weak peak at 769 (linked to C-H bending in aromatics), a band at 1802 $cm{-1}$ (possibly from C-OH stretching in alcohols or amino acids) and a peak 1313 $cm{-1}$ (C-N stretching from proteins). A C-C aromatic stretch 1479 $cm^{-1}$, C-O stretching near 2115 $cm^{-1}$ and a band at 2925 $cm^{-1}$ (related to C-H or O-H vibrations in carboxylic acids) may also be seen. In some cases, a peak around 3838 $cm^{-1}$ may appear due to O-H stretching. Altogether, the presence of these characteristic peaks, especially those at 1634 and 3284 $cm^{-1}$, provides strong evidence that sencha green tea contains important antioxidant compounds.

*3.3 Scanning Electron Microscopy (SEM)*

Based on (Hossain & mori, 2013), the scanning electron microscope (SEM) analysis is expected to produce high-resolution images that reveal the shape and surface structure of sencha loose-leaf green tea particles. Based on previous studies on used black tea leaves, which show particles with irregular and non-spherical shapes, it is likely that sencha loose-leaf green tea particles will also appear non-spherical. They may have fibrous or flaky textures and the sem images will show these surface features in detail at various magnifications. From the sem images, particle size and shape can be visually assessed. If further analysis is needed, the length and width of individual particles can be measured for more detailed size estimation. Similar to the method used for black tea leaves, around 100 particles may be analyzed to gather reliable data on particle size.

The distribution of particle sizes can also be presented in the form of histograms. These histograms would show how many particles fall within specific size ranges based on their measured dimensions. If the particles follow a pattern like a lognormal distribution, this can be used to better understand the spread of the sizes. Overall, sem analysis of sencha loose-leaf green tea is expected to provide both visual and numerical insights into the structure and surface characteristics of the tea particles.

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