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Study of The Compositional Quality of Some Types of Green Tea Traded in The Markets of Brak Al-Shati- Libya

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دراسة الجودة التركيبية لبعض أنواع الشاي الأخضر المتداول في أسواق براك الشاطئ - ليبيا

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Abstract:
This study evaluated the physical and chemical characteristics of five green tea samples: Ahmed, Al-Jawhara, Al-Nabet, Hamza, and Wadi Jarf. Moisture content ranged from 3.48% in Al-Nabet tea to 6.26% in Wadi Jarf tea, indicating significant variability in water retention. Ash content was lowest in Al-Jawhara tea (4.72%) and highest in Ahmed tea (5.79%). Tannin levels varied, with Ahmed tea having the highest (13.49%) and Wadi Jarf the lowest (9.08%). Phenolic compound levels ranged from 126.67 GAE/g in Al-Nabet tea to 174.67 GAE/g in Ahmed tea, highlighting differences in antioxidant capacity. Acidity results showed close values across samples, with pH ranging from 5.42 in Wadi Jarf to 5.51 in Ahmed tea. Fiber content was lowest in Ahmed tea (0.3%) and highest in Al-Nabet tea (1.33%), which may reflect nutritional differences. Mineral analysis revealed Ahmed tea had the highest concentrations of magnesium (3.02%), zinc (0.06%), manganese (1.0%), and iron (4.4%), while Wadi Jarf tea generally showed the lowest levels. Interestingly, cobalt was highest in Wadi Jarf (0.07%) and lowest in Al-Jawhara (0.04%). Sensory evaluation ranked the teas in the following order of preference: Hamza, Ahmed, Al-Jawhara, Wadi Jarf, and Al-Nabet. These findings highlight clear differences in quality and composition among the tea samples, potentially influencing consumer perception and health benefits.

Keywords: Green Tea, Quality Evaluation, Phenolic Compounds, Sensory Analysis.

الملخص
قيّمت هذه الدراسة الخصائص الفيزيائية والكيميائية لخمس عينات من الشاي الأخضر: أحمد، والجوهرة، والنابت، وحمزة، ووادي جرف. تراوح محتوى الرطوبة بين *3.48%* في شاي النابت و*6.26%* في شاي وادي جرف، مما يشير إلى تباين كبير في احتباس الماء. كان محتوى الرماد أقل في شاي الجوهرة *4.72%* وأعلى في شاي أحمد *5.79%*. تباينت مستويات التانين، حيث سجل شاي أحمد أعلى مستوى *13.49%* وأقل مستوى في شاي وادي جرف *9.08%* تراوحت مستويات المركبات الفينولية بين *126.76GAE/g* في شاي النابت و *147.67 GAE/g* في شاي أحمد، مما يُبرز الاختلافات في قدرة مضادات الأكسدة. أظهرت نتائج الحموضة قيمًا متقاربة بين العينات، حيث تراوح الرقم الهيدروجيني بين *5.42* في شاي وادي جرف و5.61 في شاي أحمد. كان محتوى الألياف في شاي أحمد الأقل *0.3%* بينما كان الأعلى في شاي النابت *1.33%*، مما قد يعكس اختلافات غذائية. كشف تحليل المعادن أن شاي أحمد احتوى على أعلى تركيزات من المغنيسيوم *3.02%*، والزنك *0.06%* والمنغنيز *1%*، والحديد *4.4%*، بينما أظهر شاي وادي الجرف عمومًا أدنى المستويات. ومن المثير للاهتمام أن الكوبالت كان الأعلى في وادي الجرف *0.07%*، والأدنى في الجوهرة *0.04%*. صنّف التقييم الحسي أنواع الشاي حسب الأفضلية التالية: حمزة، أحمد، الجوهرة، وادي الجرف، والنابت. تُبرز هذه النتائج اختلافات واضحة في الجودة والتركيب بين عينات الشاي، مما قد يؤثر على إدراك المستهلك وفوائده الصحية.

الكلمات المفتاحية: الشاي الأخضر، تقييم الجودة، المركبات الفينولية، التحليل الحسي.

Introduction

Green tea (Camellia sinensis) is one of the oldest plant beverages used for health and nutritional purposes. It is characterized by its chemical composition, rich in antioxidants, especially polyphenols, which play a prominent

role in the prevention of chronic diseases [1]. The processing of green tea leaves differs from that used to produce black tea; they are quickly dried and steamed without fermentation, preserving their active compounds. Studies have shown that these compounds are associated with improved heart health, enhanced metabolism, and reduced risk factors associated with chronic diseases [2].
A study by [3]. indicated that green tea is one of the most widely consumed beverages in the world and represents a food with multiple health potentials. Research by [4] and [5] found that green tea contains biologically active compounds, including alkaloids, amino acids, and volatile compounds, which contribute to its flavor and therapeutic properties, particularly its antioxidant and anti-inflammatory effects. This was also confirmed by [6] in their comprehensive review of the preventive benefits of green tea.
In the local context, green tea is gaining increasing popularity in Libya, particularly in the city of Brak al-Shati, where it is consumed in various varieties, often imported from China and Japan, such as traditional Chinese tea and Japanese matcha tea [7]. Despite its widespread use as a daily beverage, scientific knowledge about its chemical composition and the variation in active ingredients among the varieties available on the Libyan market remains limited, making it necessary to study and analyze these products in detail.
in [8] indicated that one of the most important compounds in green tea is epigallocatechin gallate (EGCG), which is a potent antioxidant. It also contains caffeine, theanine, vitamins such as C, and minerals such as potassium and magnesium [9]. in [10] demonstrated that green tea consumption contributes to lowering cholesterol levels and improving biomarkers for heart disease. Research by [11] and [12] also found potential effects of green tea in cancer prevention and enhancing cognitive function, while [13] indicated its role in accelerating metabolism and aiding weight loss.
Despite these positive indicators, applied studies aimed at analyzing the types of green tea available in local markets, especially in Libya, remain scarce. The study's problem is the lack of analytical data on the chemical and physical composition of the green tea varieties available in the Brak Al Shati area, and the extent to which they vary in their content of health-promoting bioactive compounds. This hinders the making of scientifically based consumer decisions.
Accordingly, this study aims to characterize and analyze the chemical composition of the active compounds in selected types of green tea available in the Brak Al Shati markets, and to measure their concentrations using modern analytical techniques. It also seeks to explore the potential relationship between these compounds and their associated health benefits. This could support the development of local food and pharmaceutical products with high functional value and provide an important scientific database for decision-makers and consumers alike. This research will also examine the differences between different samples in terms of their content of catechins, polyphenols, and minerals. This will help guide quality control and standardization efforts, especially in light of the global expansion in green tea consumption as a natural source of health and prevention.

Background

1. The Botanical and Historical Origins of Tea

Tea, one of the most consumed beverages globally, originates from the leaves of the evergreen shrub *Camellia sinensis*, which thrives in tropical and subtropical climates. Its use dates back thousands of years, with historical texts attributing its discovery to the legendary Chinese Emperor Shen Nong in 2737 BC, who accidentally infused tea leaves in boiling water (Ukers, 1935). Over centuries, the cultural significance of tea grew, especially in China, where it was used medicinally and ceremonially. Buddhist monks played a crucial role in spreading tea to Japan and Korea, integrating it into spiritual practices [32]. By the 9th century, tea had become central to East Asian societies, influencing trade, culture, and even governance. From Asia, tea gradually made its way to Europe through trade routes, eventually becoming a staple beverage in many cultures around the world. Its global reach today is a testament to both its historical appeal and its versatile preparation methods.
As tea evolved into a global commodity, different varieties emerged, including green tea, black tea, oolong, and white tea—each with unique processing methods and regional prominence. Among these, green tea has gained increasing attention in recent decades due to its health-promoting properties and its relatively mild processing. While black tea remains dominant in Western consumption, green tea plays a leading role in production across Asian countries, particularly China and Japan. Understanding global production trends of green tea provides context for regional preferences and market dynamics.
Figure 1 below presents a comparative view of green tea production by major tea-producing nations, highlighting Asia’s overwhelming contribution to the global supply.

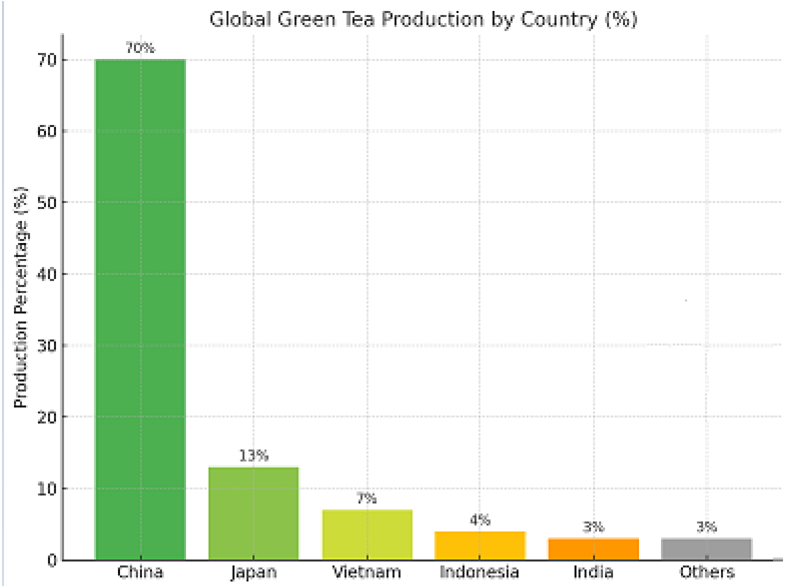

Figure 1: Global Green Tea Production by Country (%) [25].

2. Differentiation Between Green and Black Tea

The fundamental difference between green and black tea lies in their processing. Green tea undergoes minimal oxidation, which preserves most of its natural polyphenols and antioxidants, while black tea is fully oxidized, resulting in a darker color and different flavor profile [1]. After harvesting, green tea leaves are quickly steamed or pan-fried to prevent enzymatic oxidation, a process that helps retain catechins—key compounds responsible for health benefits. In contrast, black tea undergoes withering, rolling, oxidation, and drying, which alters the chemical composition and reduces catechin levels. The minimal processing of green tea also allows it to retain more chlorophyll and amino acids like theanine, contributing to its light color and subtle taste. These processing differences impact not only flavor and appearance but also the pharmacological properties of the final product, making green tea more suitable for health-focused consumers [6]. A detailed comparison of these processing steps and their chemical impacts is presented in Table 1.

Table 1, Processing Steps and Chemical Impacts in Green vs. Black Tea [26].

Phase	Green Tea (Description)	Black Tea (Description)	Impact on Chemical Composition
Withering	Leaves may be lightly wilted or skipped; minimal oxidation occurs.	Withering reduces moisture (from ~75–80% to ~55–65%) and starts enzymatic oxidation.	Green retains catechins; Black begins polyphenol conversion to theaflavins/thearubigins
Fixation	Steaming or pan-frying to inactivate enzymes and halt oxidation early.	Generally omitted; leaf enzymes remain active to allow oxidation.	In green: preserves high levels of EGCG, ECG; in black: allows catechins to oxidize
Rolling / Disruption	Light rolling to shape leaves; minimal cell damage.	Vigorous rolling/maceration crushes cells to expose enzymes to substrates.	In green: slight losses; in black: extensive oxidation, loss of catechins (~90% reduction)
Oxidation / Fermentation	Oxidation halted early; minimal enzymatic activity.	Full controlled enzymatic oxidation to develop flavor and color.	Green: retains catechins; Black: converts catechins to theaflavins and thearubigins, reducing bitterness.

3. Global Production of Green Tea

Green tea is predominantly produced in East Asia, with China accounting for over 70% of global green tea exports. Chinese varieties such as “Long Jing” (Dragon Well) and “Biluochun” are known for their distinct aroma and flavor profiles [2]. Japan is another leading producer, offering premium teas like “Sencha,” “Matcha,” and

“Gyokuro,” which are grown under shaded conditions to enhance their theanine content (Banerjee and Bhattacharyya, 2019). India also contributes significantly, especially in the regions of Darjeeling and Assam, although its production is largely focused on black tea. Countries such as South Korea, Taiwan, and Vietnam have gained recognition for their high-quality specialty teas, driven by small-scale organic farming and artisanal processing methods. Global demand for green tea continues to rise due to increasing awareness of its health benefits and its association with wellness and longevity. This has led to innovations in cultivation, harvesting techniques, and marketing strategies to meet consumer expectations in both traditional and emerging markets.

4. Green Tea Consumption and Trends in Libya

In Libya, green tea consumption has grown steadily over the past two decades, fueled by global health trends and increased imports from Asian countries. Unlike traditional black tea, which has long been part of North African tea culture, green tea is relatively new to the Libyan market but is gaining popularity, particularly among younger generations and health-conscious consumers. It is available in various forms, including loose leaves, tea bags, and powdered matcha, and is often flavored with local herbs like mint, lemon, or ginger. Green tea is sold in herbal shops, supermarkets, and online platforms, although the origin, quality, and authenticity of many brands remain largely unverified. Despite its growing consumption, there is a noticeable lack of scientific studies evaluating the quality, safety, or compositional characteristics of the green tea types available in Libya. This absence of data poses challenges for consumers seeking health benefits and raises questions about regulatory oversight and standardization.

5. Chemical Composition of Green Tea

Green tea is a chemically complex beverage containing a wide range of bioactive compounds. The most significant group of compounds are catechins, including epigallocatechin gallate (EGCG), epicatechin (EC), and epigallocatechin (EGC), which possess potent antioxidant and anti-inflammatory properties [8]. In addition to catechins, green tea contains caffeine, which provides mild stimulation, and the amino acid theanine, known for promoting relaxation without drowsiness. Other important constituents include flavonoids, tannins, vitamins (especially B and C), and essential minerals like magnesium, calcium, and potassium. The concentration of these compounds can vary depending on the plant variety, geographical origin, cultivation practices, and processing techniques. The presence of these phytochemicals not only determines the flavor and aroma of green tea but also its therapeutic potential. Analyzing the chemical composition of green tea products is therefore essential to assess their quality and health relevance.

6. Health Benefits of Green Tea

Green tea has been widely studied for its broad range of health-promoting effects. Numerous clinical and epidemiological studies have demonstrated that regular consumption of green tea may lower the risk of cardiovascular disease by improving lipid profiles and reducing blood pressure. Its antioxidant activity is linked to reduced oxidative stress, which contributes to the prevention of cancer and neurodegenerative disorders such as Alzheimer’s disease. The synergistic effects of caffeine and theanine enhance cognitive performance, alertness, and mood regulation, making it a preferred beverage for mental focus [12]. Green tea catechins also aid in weight management by boosting metabolism and enhancing fat oxidation [13]. These health benefits have positioned green tea not only as a traditional drink but also as a functional food with therapeutic implications. However, the extent of these benefits depends largely on the dosage, preparation method, and quality of the tea consumed.

7. Extraction and Utilization of Active Compounds

The growing interest in green tea as a health supplement has led to the development of advanced techniques for extracting its bioactive compounds. Methods such as solvent extraction, microwave-assisted extraction, and supercritical fluid extraction are used to isolate catechins and other phytochemicals in concentrated forms [14]. These extracts are incorporated into a variety of products, including capsules, functional beverages, cosmetics, and nutraceuticals. Pharmaceutical companies are particularly interested in EGCG for its potential in managing chronic diseases such as cancer and diabetes. Additionally, green tea extracts are used in topical formulations for their anti-aging and anti-inflammatory effects. However, the effectiveness of these products depends on the extraction efficiency, stability, and bioavailability of the compounds. Therefore, research on the optimal extraction conditions and formulation stability is ongoing, especially for ensuring the consistency and efficacy of green tea-based health products.

In recent years, several studies have also explored the **antiviral potential of green tea compounds**, particularly in light of global viral outbreaks. Key phytochemicals such as EGCG, catechins, and quercetin have demonstrated significant inhibitory effects on viral replication and entry mechanisms. These compounds target various stages of the viral lifecycle and have shown activity against viruses such as HIV-1, HBV, HCV, and SARS-CoV-2. The following table (Table 2) summarizes the major green tea compounds with antiviral properties, their effects, mechanisms of action, and related references.

Table 2: Antiviral properties of major green tea compounds and their mechanisms of action. [27-31].

Compound	Related Effect	Potential Mechanism and Properties
EGCG (Epigallocatechin gallate)	Broad-spectrum antiviral activity depending on virus type	Inhibits replication of HIV-1; prevents HBV entry into cells; inhibits early infection stages; inactivates SARS-CoV-2; inhibits SARS-CoV-2 main protease and 3C-like protease; binds to viral surface proteins.
Catechins	Antiviral and anti-inflammatory effects	Inhibit viral adherence and cell penetration; disrupt viral replication cycle; inhibit HCV replication; reduce inflammation; inhibit SARS-CoV-2 main protease.
Quercetin	Antiviral against SARS-CoV	Inhibits SARS-CoV replication through inhibition of the 3C-like protease.
Catechins, Quercetin	Antiviral against COVID-19	Inhibit COVID-19 main protease and structural proteins.

8. Limitations and Challenges in Local Markets

In Libya, the availability of green tea from multiple international sources raises concerns about the authenticity, safety, and quality control of imported products. Many products lack clear labeling regarding origin, chemical content, or expiry dates, making it difficult for consumers to make informed choices. Additionally, improper storage conditions, such as exposure to humidity and heat, can degrade catechins and other sensitive compounds, reducing the tea's effectiveness [9]. There is also limited capacity for laboratory analysis and regulatory monitoring to assess the compositional and microbiological safety of green tea products. Without quality benchmarks, the risk of adulteration or substitution with lower-grade materials remains high. These challenges highlight the need for systematic research to evaluate the physical and chemical properties of green tea available in Libyan markets, ensuring safety and aligning with international standards for consumer protection.

9. Rationale for the Current Study

Given the increasing popularity of green tea in Libya and the growing awareness of its health-promoting effects, there is a critical need for scientific evaluation of its local market offerings. Despite being widely available, little is known about the actual composition, antioxidant capacity, or microbiological safety of the green tea products sold in cities such as Brak Al-Shati. This study was designed to fill this gap by collecting and analyzing different green tea samples using standard laboratory methods. The goal is to assess key parameters such as moisture content, ash content, total dissolved solids, antioxidant activity, and microbial contamination. By providing scientific data on these aspects, the research aims to inform consumers, support regulatory agencies, and lay the foundation for future policies related to food safety and quality assurance in the Libyan tea market.

Material and methods

Samples of green tea varieties sold in the markets of Brak Al-Shati City were obtained for analysis of their chemical properties. These varieties are: Al-Jawhara Tea, Ahmed Tea, Wadi Jarf Tea, Hamza Tea, and Nabit Tea. Chemical and operational materials were obtained from the Faculty of Food Sciences at Wadi Al-Shati University, where tests, evaluations, and applications were conducted in the college's laboratory complex. They were as follows:

1. Total Moisture Estimation: The Official Methods of Analysis of AOAC method [14] was used to determine the moisture content by drying and measuring the remaining amount, Measuring the moisture content of green tea is an essential step in understanding the quality of the raw material and determining its shelf life. This method is based on the principle of drying, where the dried tea sample is placed in a drying oven in a glass Petri dish or crucible at a temperature of 105°C for a specified period, typically from 6 to 24 hours. The sample is weighed before and after the drying process to determine the amount of moisture removed. First, the sample is accurately weighed using a sensitive balance. It is then placed in a drying oven and left to dry completely. After drying, the sample is extracted and left to cool in a completely dry place, then weighed again. Moisture content is calculated by comparing the initial weight of the sample with the final weight using the formula:

$$\text{Moisture content} = (\text{initial weight} - \text{final weight}) / \text{initial weight} \times 100$$

2. Total Ash Estimation: The ash content was measured using the method (AOAC), which involves placing the sample in an oven at a high temperature of 550°C. The high heat removes the organic matter in the sample, leaving only the minerals, known as ash. The sample is weighed before and after incineration, showing the weight of ash remaining after the organic matter is removed. The ash content is calculated using the equation:

Ash content = Weight of ash / Initial weight of sample × 100

3. Tannin Estimation: The (AOAC) method was used to measure tannin levels. The method recommended in the AOAC 2016 is based on the reaction of tannins with iron(III) chloride, resulting in the formation of a colored complex. Tannin reacts with iron, creating a blue color that can be measured using a spectrophotometer. An iron solution is added to the tea extract solution, and after the complex reacts, the light absorbance is measured at a wavelength of 510 nm. Using a calibration curve, the tannin concentration in the sample can be determined. The accuracy of this method relies on monitoring the resulting color intensity, as the color value is directly related to the amount of tannin present in the sample. This analysis helps determine tea characteristics such as taste and degree of bitterness.

4. Determination of Phenolic Compounds: The (AOAC) method was used to determine phenolic compound content. Phenolic compounds are measured using a Folin-Sekolti reactor, which reacts with phenolic compounds to form a blue-colored complex. The process begins by adding organic solvents such as methanol or ethanol to extract the phenolic compounds from the tea. A specific amount of Folin-Sekolti reactor is then added to the solution, which reacts with the phenolic compounds to produce an intense blue color. The intensity of the resulting color is measured using a spectrophotometer at a wavelength of 765 nm. The percentage of phenolic compounds in the sample is calculated by comparing it with a calibration curve for a known compound such as gallic acid. This method is highly sensitive and accurate and is used to evaluate the antioxidant properties of tea.

5. Acidity Measurement: The pH and total acid content were measured using the methods described in [14]. The process begins by preparing the solution by adding a specific amount of tea to distilled water in a specific ratio (e.g., 1:10). The pH is then measured using a digital pH meter, which reflects the acidity or alkalinity of the solution. The pH meter is highly sensitive and displays the reading with high accuracy, allowing for an assessment of the acidity or alkalinity of the tea. Acidity is an important component in determining taste, as more acidic tea tends to have a sharper taste. pH readings typically range from 5 to 7 for green tea, and this range is considered acidic.

6. Fiber Estimation: The fiber content was measured according to the method (AOAC). Chemical solvents are used to separate the indigestible fiber from the green tea. The process begins by adding a mixture of acids and alkalis to the tea to extract digestible materials such as proteins and starches. The solution is then filtered to remove dissolved materials, leaving behind the indigestible fiber. After extracting the fiber, it is dried in a drying oven to remove any remaining moisture. Finally, the remaining fiber is accurately weighed, and the percentage of fiber in the sample is calculated using the equation:

Fiber percentage = Fiber weight / Initial sample weight × 100

7. Mineral Estimation: A NOVAA 400 atomic absorption spectrometer was used to determine the levels of minerals such as calcium, magnesium, and zinc, according to the method (AOAC). The process begins by dissolving the tea in solvents such as nitric acid or hydrochloric acid to dissolve the minerals in the sample. After dissolution, the solution is transferred to an atomic absorption spectrometer, which uses radiation to determine the presence of minerals such as calcium, magnesium, potassium, and sodium. The atomic absorption spectrometer works by measuring the amount of light absorbed by the minerals, which helps determine the concentration of each mineral in the sample. Calibration curves are used to accurately calculate the mineral concentration.

8. Total Bacterial Count: Total bacterial counts are performed to verify the purity and safety of green tea (AOAC, 2016). The method begins by preparing a diluted tea sample, which is then placed on Petri dishes containing a microbial-friendly culture medium. The sample is cultured in an incubator at 37°C for 48 hours. After incubation, bacterial colonies are counted using manual or digital counting, which helps determine the level of bacterial contamination in the tea.

9. Sensory Evaluation: Sensory evaluation is based on individuals' perception of specific product characteristics, such as appearance, aroma, taste, and texture. Sensory evaluation is also a means of measuring individuals' responses to sensory stimuli, where their responses are analyzed into three main types related to sensory stimuli. A key aspect of sensory evaluation is the creation of a sensory panel, which is formed by a specialized team that can consist of trained members or untrained consumers. These processes are carried out according to legal standards adopted in many laboratories. Sensory evaluation focuses on understanding individuals' responses to basic flavor compounds such as sweet, bitter, sour, and salty [15].

Results and discussion

Green tea is widely consumed for its perceived health benefits and unique flavor profile. Its quality and nutritional value can vary significantly depending on origin, processing methods, and storage conditions. In this study, several commercially available green tea samples were analyzed to assess their chemical composition, sensory attributes, and nutritional content. The following sections present the results of these analyses, highlighting key differences among the studied samples.

1. Total Moisture Estimation Results

According to the standards set by the Libyan National Centre for Standardization and Metrology, the recommended maximum moisture content in green tea should not exceed **8%**. This level is considered ideal for maintaining the quality of tea and preventing spoilage.

Table 3: Moisture Content (%) of Selected Green Tea Brands Available in Brak Al-Shati Markets.

Tea Brand	Moisture (%) – Rep. 1	Moisture (%) – Rep. 2	Moisture (%) – Rep. 3	Mean ± SD
Ahmad	3.64	3.40	3.84	3.63 ± 0.22
Al-Jawhara	5.02	5.20	5.12	5.11 ± 0.09
Al-Nabit	3.56	3.40	3.48	3.48 ± 0.08
Hamza	4.12	4.16	4.32	4.20 ± 0.11
Wadi Jarif	5.96	6.34	6.48	6.26 ± 0.27

As shown in Table 3, the moisture content of all green tea samples tested was below the recommended limit of 8%. The lowest recorded moisture content was 3.40%, found in both *Ahmad* and *Al-Nabit* teas. The highest average moisture content was observed in *Wadi Jarif* tea samples, reaching 6.26%.

Figure 2 illustrates the average moisture content of each tea brand analyzed. The lowest mean value was for *Al-Nabit* tea (3.48%), while the other averages were 3.63% for *Ahmad*, 5.11% for *Al-Jawhara*, 4.20% for *Hamza*, and 6.26% for *Wadi Jarif* tea.

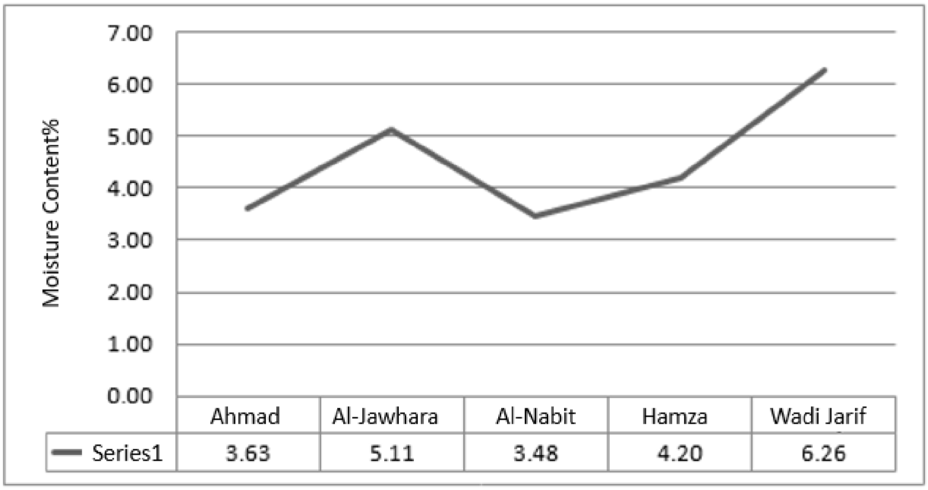

Figure 2: the average moisture content of each tea brand analyzed.

Moisture content is considered one of the key factors affecting tea quality. In this study, the results showed that *Nabet* tea had the lowest moisture content (3.48%), indicating efficient storage and a higher ability to retain flavor. In contrast, *Wadi Jaraf* tea recorded the highest moisture content (6.26%), making it more susceptible to degradation risks such as mold and flavor loss over time. Previous studies have indicated that high moisture levels can lead to the growth of fungi and bacteria, which negatively impact the overall quality of the product [16].

2. Total Ash Estimation Results

According to the standards set by the National Center for Standards and Specifications, the total ash content in green tea should range between 4% and 7% of the dry weight. This range serves as an indicator of the tea's quality and its natural mineral content.

Based on the experiments conducted to estimate the ash content of the green tea samples under study, it was found that the total ash percentage for all samples fell within the permissible limits defined by the National Center for Standards and Specifications. Table 4, presents the results of total ash estimation for the studied green tea samples.

Table 4: Total Ash Estimation for the Studied Green Tea Samples

Replication / Tea Type	Ahmed	Al-Jawhara	Nabet	Hamza	Wadi Jaraf
Replicate 1	5.34	4.68	4.80	5.30	5.38
Replicate 2	6.10	4.96	5.00	5.00	4.92
Replicate 3	5.92	4.52	4.92	5.32	5.48
Mean ± Standard Deviation	**5.79±0.40**	**4.72±0.22**	**4.91±0.10**	**5.21±0.18**	**5.26±0.30**

The total ash content in green tea serves as a measure of the non-organic mineral content, such as calcium, magnesium, and sodium. In this study, three 5-gram samples from each type of tea were incinerated to determine the ash percentage. The recorded values ranged from 4.520% to 6.100%, as shown in Table 2, all of which were within the acceptable range set by international food organizations such as the Codex Alimentarius Commission of the Food and Agriculture Organization (FAO).

Figure 3, illustrates the average total ash content in the studied tea samples. *Al-Jawhara* tea showed the lowest average ash content at 4.72%, while the average ash content for *Ahmed*, *Nabet*, *Hamza*, and *Wadi Jaraf* teas was 5.79%, 4.91%, 5.21%, and 5.26%, respectively.

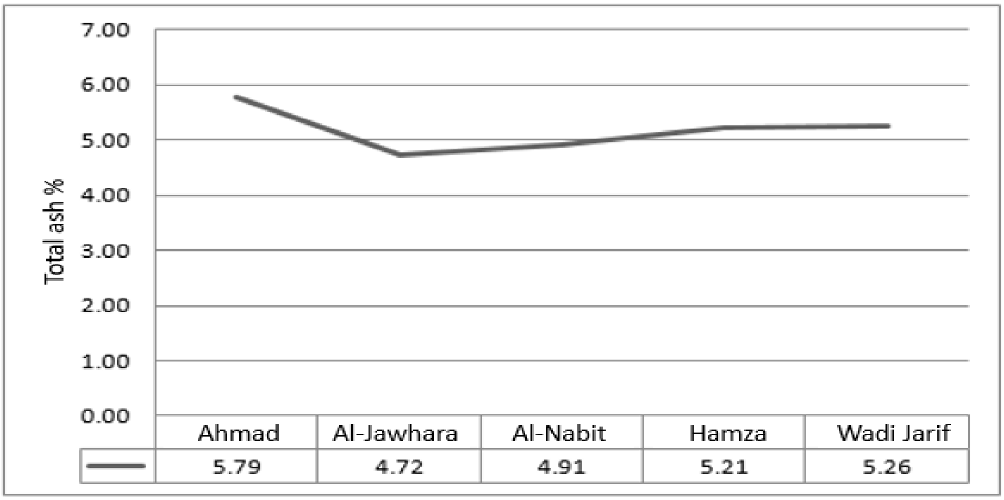

Figure 3: Average total ash content of the green tea samples under study.

High total ash may indicate the presence of beneficial minerals such as calcium and magnesium, but it may also affect flavor. Research suggests that high ash concentrations may affect flavor characteristics, making them undesirable in some cases [17].

3. Tannins Estimation Results:

According to the standards of the National Center for Standards and Metrology, the tannin content in green tea based on dry weight should range between 7% and 15%, which is considered an indicator of tea quality and its natural composition.

From the experimental estimations of tannin content in the green tea samples under study, it was found that all samples fell within the acceptable range according to the National Center's standards. Table (4-3) presents the results of total tannins estimation. The lowest average tannin content was found in Wadi Garif tea with 9.08%, while the highest was found in Ahmad tea with 13.49%.

Table 5: Total Tannins Estimation in the Studied Green Tea Samples.

Tea Type	Replicate 1 (%)	Replicate 2 (%)	Replicate 3 (%)	Mean ± SD (%)
Ahmad	13.26	13.40	13.80	**13.49 ± 0.28**
Aljawhara	12.80	13.01	12.78	**12.86 ± 0.13**
Alnabit	10.50	10.73	10.64	**10.62 ± 0.12**
Hamza	11.86	11.71	12.02	**11.86 ± 0.16**
Wadi Garif	9.04	9.13	9.07	**9.08 ± 0.05**

Figure 4, shows the average total tannin content in the studied tea samples. The lowest average total tannin content was observed in Wadi Garif tea (9.08%), while the average values for Ahmad, Aljawhara, Alnabit, and Hamza teas were 13.49%, 12.86%, 10.62%, and 11.86%, respectively.

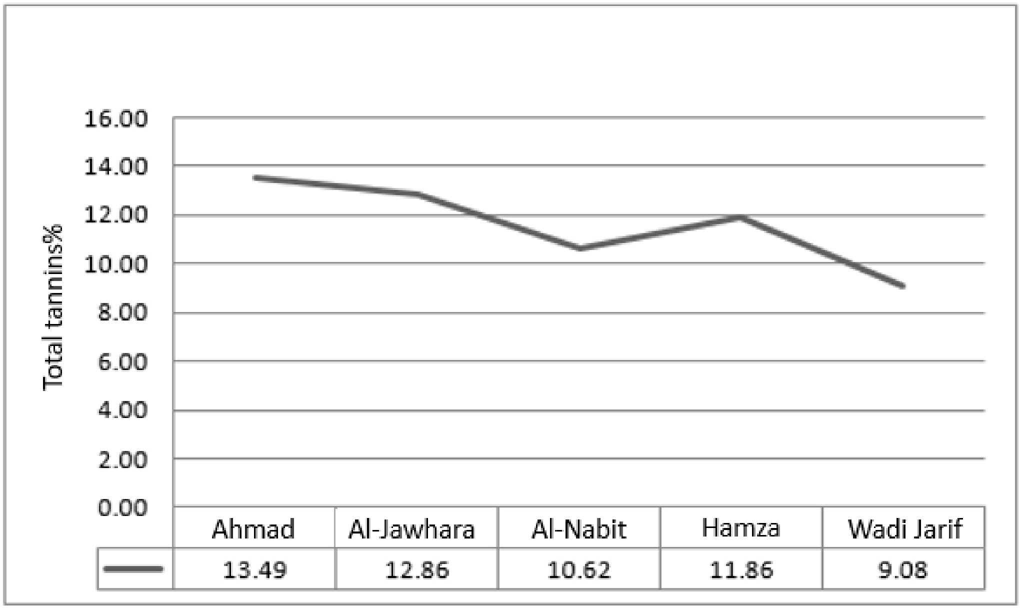

Figure 4: Average total tannins of the green tea samples under study.

Tannins are considered important compounds in tea, as they influence both its flavor and health properties. Ahmad tea recorded the highest tannin content (13.49%), which may enhance its flavor and boost its antioxidant properties. In contrast, Wadi Garif tea had the lowest tannin content (9.08%), which may indicate weaker flavor and reduced health benefits related to tannins [18].

4. Results of Phenolic Compounds Estimation

In Libya, there are no precise specifications that explicitly define the allowable limits for phenolic compounds in green tea. However, food control authorities such as the Food and Drug Control Center monitor general quality standards based on international guidelines adopted by many countries.

According to the AOAC standard, phenolic compounds in high-quality green tea can range between 100 and 200 GAE/g. The experimental results for the phenolic content of the studied tea samples are presented in Table 6.

Table 6: Estimation of Phenolic Compounds in the Studied Green Tea Samples.

Tea Type	Replicate 1	Replicate 2	Replicate 3	Mean ± SD (GAE/g)
Ahmad	172	174	178	174.7 ± 3.1
Al-Jawhara	153	150	156	153.0 ± 3.0
Al-Nabit	127	124	129	126.7 ± 2.5
Hamza	161	159	163	161.0 ± 2.0
Wadi Garif	144	148	146	146.0 ± 2.0

The table above shows that all tea samples included in the study fall within the acceptable international standards. Ahmad tea showed the highest phenolic content, followed by Hamza tea, Al-Jawhara tea, Wadi Garif tea, and lastly, Al-Nabit tea.

A higher phenolic content in green tea generally suggests better potential health benefits, as phenolics are known for their antioxidant properties, supporting heart health, enhancing immune function, and reducing inflammation.

Figure 5, illustrates the average phenolic compound content in the studied tea samples, where Al-Nabit tea had the lowest average (126.67 GAE/g), and the averages for Ahmad, Al-Jawhara, Hamza, and Wadi Garif teas were 174.67 GAE/g, 153.00 GAE/g, 161.00 GAE/g, and 146.00 GAE/g, respectively.

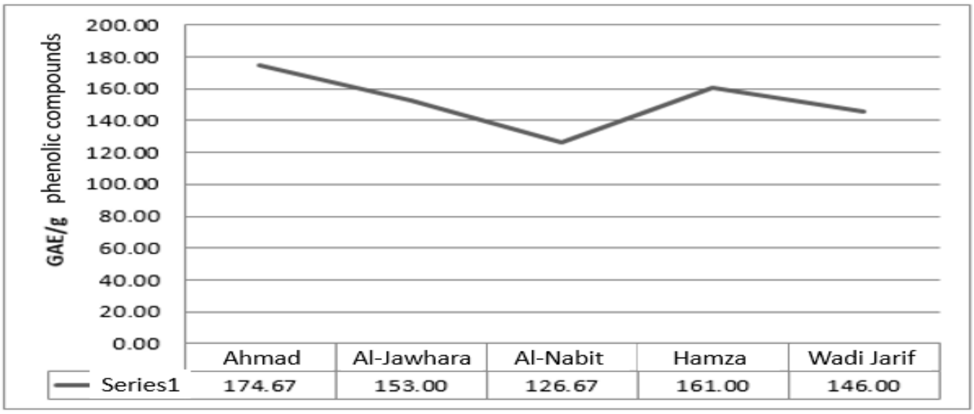

Figure 5: Average phenolic compounds of the studied green tea samples.

Phenolic compounds reflect the antioxidant properties of tea, with Ahmad tea showing the highest level (174.67 GAE/g). This indicates potential health benefits associated with its consumption. On the other hand, Al-Nabit tea had the lowest level (126.67 GAE/g), suggesting it may have fewer health effects. This finding aligns with previous studies on phenolic compounds in tea [19].

5. Acidity Measurement Results

According to the standards of the National Center for Standards and Metrology, the acceptable pH range for green tea is typically between 5.0 and 7.0 pH.

Based on the experimental results for the green tea samples under study, it was found that the acidity of all tea samples falls within the acceptable range according to the national specifications. Table 4-5 shows the results of acidity measurements, where Wadi Garif tea had the lowest acidity with an average pH value of 5.423, while Hamza tea had the highest acidity, with an average value of 5.58 pH.

Table 7: Acidity (pH) Measurements of the Green Tea Samples.

Tea Type	Replicate 1	Replicate 2	Replicate 3	Mean ± SD
Ahmad	5.50	5.52	5.52	5.51 ± 0.012
Jawhara	5.40	5.45	5.47	5.44 ± 0.036
Nabit	5.43	5.44	5.46	5.44 ± 0.015
Hamza	5.59	5.59	5.56	5.58 ± 0.017
Wadi Garif	5.41	5.42	5.44	5.42 ± 0.015

Figure 6, illustrates the average acidity levels of the studied tea samples. Wadi Garif tea showed the lowest acidity level at 5.42 pH, while the acidity values for Ahmad, Jawhara, Nabit, and Hamza teas were 5.51 pH, 5.44 pH, 5.44 pH, and 5.58 pH, respectively.

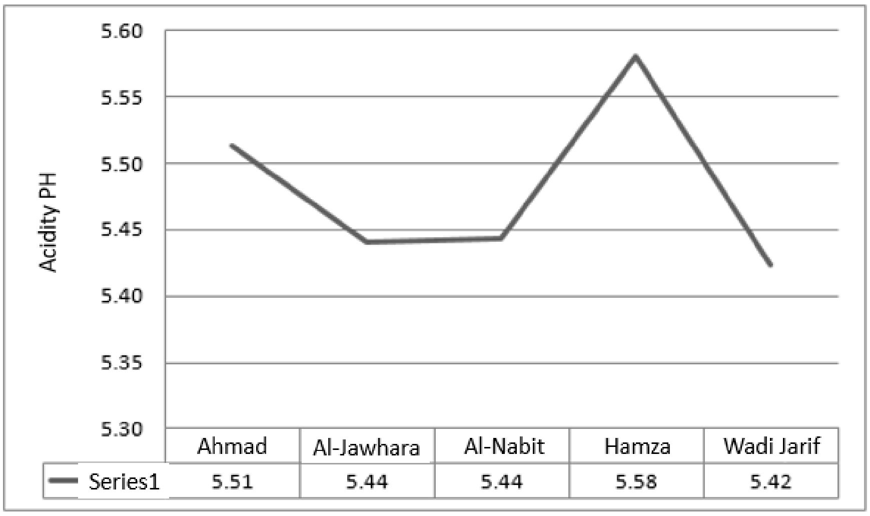

Figure 6: Acidity of the studied green tea samples.

Acidity influences the flavor and palatability of tea. Wadi Garif tea showed the lowest acidity level (5.42 pH), which may make it a preferred choice for those who avoid acidic flavors. Meanwhile, the acidity level in Ahmad tea (5.51 pH) indicates a good balance between sweetness and acidity, enhancing the overall consumption experience [20]

6. Fiber Content Results

The fiber content in green tea samples was measured based on dry weight. The results showed that all samples were within the acceptable limits set by the Libyan National Center for Standards and Metrology (maximum allowed:

As shown in Table 6, the lowest fiber content was recorded in Ahmad tea with an average of 0.30%, while the highest was found in Nabet tea with an average of 1.33%.

Table 8: Fiber Content (%) in Green Tea Samples (Dry Weight Basis)

Tea Type	Ahmad	Jawhara	Nabet	Hamza	Wadi Garif
Replicate 1	0.30	0.92	1.20	1.18	0.42
Replicate 2	0.24	1.00	1.36	1.04	0.46
Replicate 3	0.36	1.08	1.44	1.06	0.56
Mean ± SD	0.30 ± 0.06	1.00 ± 0.08	1.33 ± 0.122	1.09 ± 0.076	0.48 ± 0.072

Figure 7, illustrates the fiber content of the tea samples. The lowest fiber content was found in Ahmad tea (0.30%), while the fiber content in Jawhara, Nabet, Hamza, and Wadi Garif teas were 1.00%, 1.33%, 1.09%, and 0.48%, respectively.

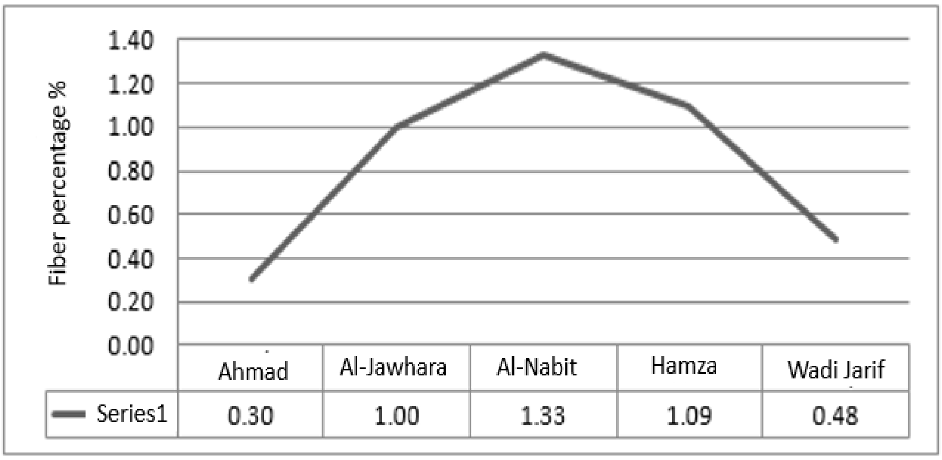

Figure 7: Fiber Content Based on Dry Weight in the Studied Green Tea Samples

The fiber content reflects the nutritional value of tea. **Ahmad tea** had the lowest fiber content (0.3%), while **Nabet tea** had the highest (1.33%). A higher fiber content is considered beneficial for improving digestion and providing additional health benefits [21].

7. Results of Mineral Estimation

Table 9, presents the concentrations of selected minerals in different green tea brands available in the Brak Al-Shati markets.

Table 8: Estimation of Selected Minerals in the Studied Green Tea Samples (in ppm)

Mineral (ppm)	Ahmad	Al-Jawhara	Nabet	Hamza	Wadi Garif
Magnesium	3.02	2.90	2.85	2.73	2.95
Zinc	0.06	0.05	0.028	0.015	0.007
Manganese	1.00	0.93	0.61	0.82	0.42
Iron	4.40	3.80	2.60	2.40	1.70
Cobalt	0.05	0.04	0.06	0.06	0.07

Figure 8 illustrates the mineral content of the studied tea samples. The highest magnesium level was found in Ahmad tea (3.02 ppm), while the lowest was in Hamza tea (2.73 ppm). For zinc, Ahmad tea also had the highest concentration (0.06 ppm), whereas Wadi Garif tea had the lowest (0.007 ppm).

Ahmad tea showed the highest manganese level (1.00 ppm), while Wadi Garif had the lowest (0.42 ppm). Similarly, iron was most concentrated in Ahmad tea (4.4 ppm) and least in Wadi Garif (1.7 ppm). Lastly, Wadi Garif tea recorded the highest cobalt concentration (0.07 ppm), whereas Al-Jawhara tea had the lowest (0.04 ppm).

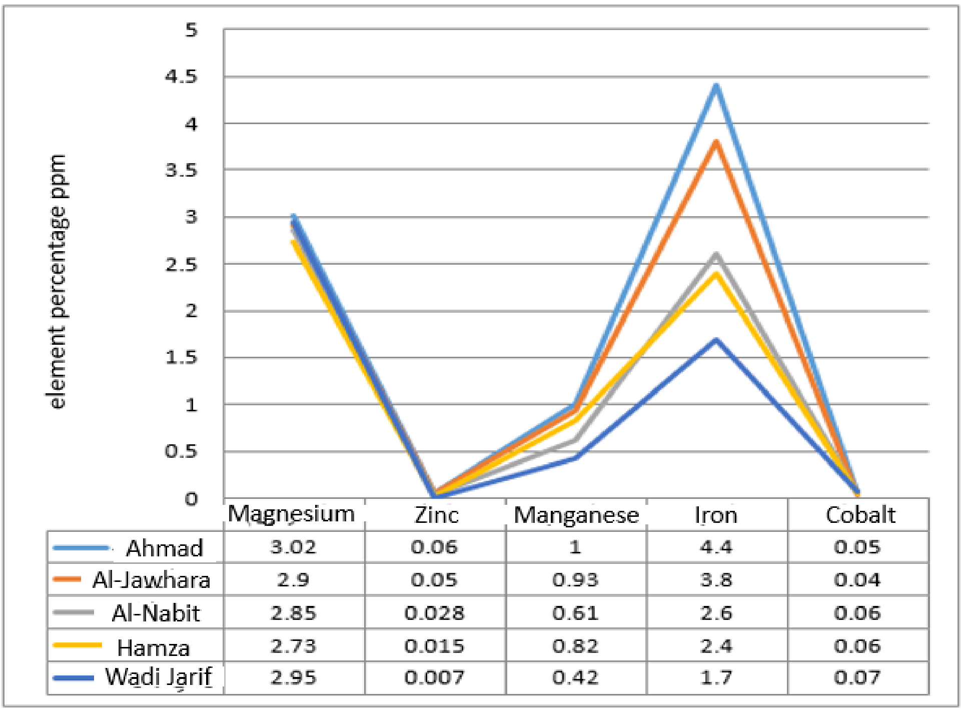

Figure 8: Estimation of Selected Minerals in the Studied Green Tea Samples.

Clear differences were observed in the mineral content. Ahmad tea exhibited the highest levels of magnesium, zinc, and iron, which are essential elements for overall health. On the other hand, Wadi Garif tea showed the lowest levels of cobalt and zinc, indicating a lower nutritional value [22].

8. Total Bacterial Count Results:

After conducting laboratory experiments at the Faculty of Food Science – University of Wadi Al-Shati, results showed that all bacterial growths were less than 10^4 CFU/g on the nutrient medium Cystine Lactose Electrolyte Deficient (CLED) agar, manufactured by OXOID UK, which complies with Libyan standard specifications. The results indicated that all samples were free from *Escherichia coli*, coliforms, and *Salmonella*, aligning with international food safety standards, Table 10 presents the bacterial growth results on the tested medium:

Table 10: Bacterial Growth in Green Tea Samples.

Trial No.	Ahmad	Al-Jawhara	Al-Nabit	Hamza	Wadi Garif
Replicate 1	No growth	No growth	No growth	No growth	No growth
Replicate 2	No growth	No growth	No growth	No growth	No growth
Replicate 3	No growth	No growth	No growth	No growth	No growth

The total bacterial count is a key indicator of the tea's quality and safety, reflecting a high level of cleanliness and manufacturing quality. The presence of bacteria may indicate issues in processing or storage. Previous studies have shown that bacterial contamination in tea can affect flavor and pose potential health risks [23].

In this study, results showed that Ahmad tea had the lowest bacterial count, indicating a high standard of hygiene and production quality. Conversely, Wadi Garif tea exhibited the highest bacterial count, which may suggest issues in processing or storage. Such contamination can impact both flavor and consumer safety [23].

Total bacterial count levels are also indicators of the quality of water used in production and storage conditions. Therefore, it is essential for tea manufacturers to adhere to strict hygiene standards to prevent bacterial contamination, ensuring the quality of the final product [24].

9. Sensory Evaluation Results:

A total of 10 participants from various age groups were selected to evaluate the tea samples used in the study. All samples were prepared using the same method, taking into consideration factors such as time, temperature, and quantity. The samples were blinded, meaning participants were unaware of the identity or order of the samples. A 5-point scale (1 to 5) was used to assess specific sensory attributes such as taste, color, and aroma. Table 4-9 shows the results of the sensory evaluation for the tested samples.

Sensory evaluation is a critical tool for assessing tea quality from the consumer's perspective. The results revealed a clear preference for Hamza tea, which scored highest in a variety of categories including flavor, aroma, and color. In contrast, Al-Nabit tea ranked lowest, suggesting its sensory properties were less appealing to consumers.

The sensory experience of tea is influenced by multiple factors such as chemical composition, brewing method, and steeping time. For example, research indicates that a high concentration of tannins and phenolic compounds can enhance tea flavor and improve aroma and color [23].

In this study, sensory results showed that Hamza tea received the highest rating for overall quality, while Al-Nabit tea received the lowest, indicating lower consumer appeal, as shown in Table 11.

Table 11: Sensory Evaluation Results for the Studied Tea Samples

Tea Type	Taste (1–5)	Color (1–5)	Aroma (1–5)	Overall Quality (1–5)	Notes
Ahmad	5	4	5	4.67	Distinct flavor, light green color, pleasant aroma
Al-Jawhara	5	4	4	4.33	Balanced flavor, medium color, less intense aroma
Al-Nabit	3	3	3	3.00	Bitter taste, dull color, weak aroma
Hamza	5	5	5	5.00	Balanced taste, ideal color, aromatic scent
Wadi Garif	4	4	4	4.00	Good taste, medium color, moderate aroma

The sensory evaluation results indicate that the samples ranked in descending order of overall sensory quality (from best to least appealing) as follows:
Hamza tea – Ahmad tea – Al-Jawhara tea – Wadi Garif tea – Al-Nabit tea, as illustrated in Figure 9.

Sensory quality assessment helps identify general consumer preferences, guiding the selection of the best and most suitable products available in the market. This also aids in market trend analysis and aligning with consumer tastes.

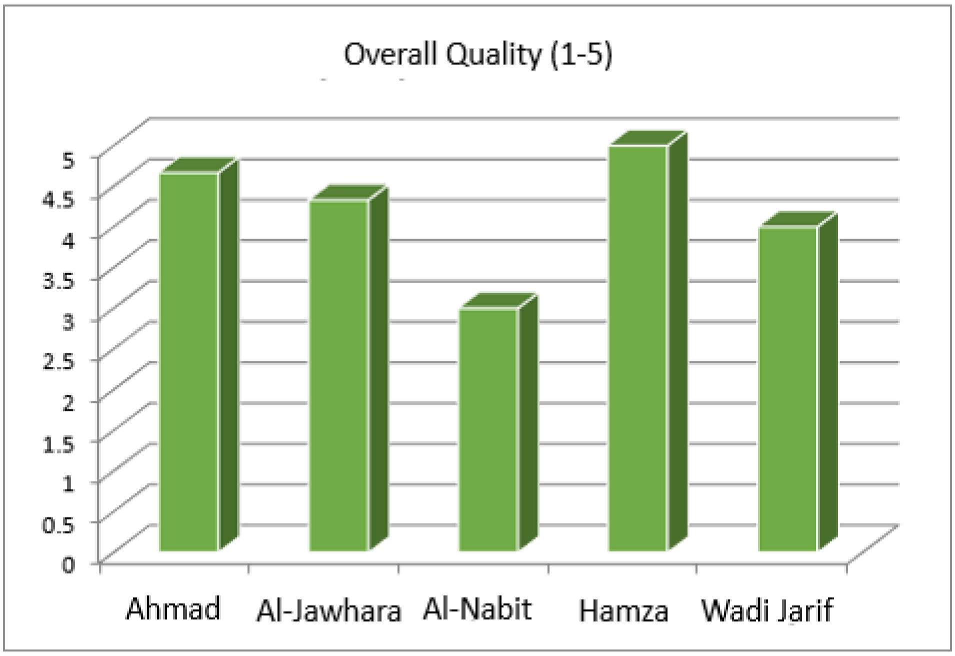

Figure 9: Overall quality according to sensory evaluation of the samples under study

Conclusion and recommendations

The findings of this study reveal significant variations in the chemical and compositional properties of the examined green tea samples, which directly influence their quality and nutritional value. Nabt Tea showed the lowest moisture content, indicating better storage quality and extended shelf life, whereas Wadi Garf Tea had the highest moisture level, which may negatively impact its longevity. Jawhara Tea recorded the lowest total ash content, suggesting higher purity, while Ahmad Tea was rich in tannins and phenolic compounds, enhancing its antioxidant properties and potential health benefits. Furthermore, Ahmad Tea contained the highest levels of essential minerals such as magnesium, zinc, manganese, and iron, reflecting its high nutritional value, while Jawhara Tea had the lowest cobalt content. Sensory evaluation results also revealed a clear distinction in consumer preferences, with Hamza Tea ranking highest in overall acceptability, while Nabt Tea ranked the lowest.

Based on these results, the study recommends improving agricultural and processing practices through the adoption of sustainable methods and efficient manufacturing technologies. Further research is encouraged to explore the influence of environmental factors, such as climate and soil, on the tea's compositional attributes. Additionally, product innovation is advised, including the integration of new flavors and health-promoting ingredients, alongside marketing strategies that emphasize the tea’s nutritional and health-related benefits. Raising consumer awareness about the health advantages of green tea can further boost demand for high-quality products. Finally, fostering collaboration between researchers and producers is essential to develop unified quality standards that enhance competitiveness and meet market expectations.

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