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DETERMINATION OF MINERAL AND TRACE ELEMENTS IN TEMI TEA (*CAMELLIA SINENSIS*) SAMPLES FROM SIKKIM, INDIA

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ABSTRACT

The present study was conducted during 2017-2018 at Department of Horticulture, Sikkim University, India to assess and quantify the level of mineral and trace elements in different flushes samples of Temi tea by ICPMS. Tea (*Camellia sinensis*) is a popular beverage worldwide due to its refreshing, stimulant and medicinal properties. In terms of human intake of several nutritional trace elements, tea is a significant factor. Temi tea is a premium organic tea brand grown in Sikkim which has high demand in the international trade. In this study the content different mineral and trace elements like Calcium (Ca), Sodium (Na), Boron (B), Silicon (Si) and Selenium (Se) were analysed through ICPMS in different flushes samples of Temi tea. The Calcium content ranged from 16.80±12.56 to 29.12±6.13 mg kg^{-1}, Sodium content ranged from 1.65±0.79 to 3.40±1.97 mg kg^{-1}, Boron content ranged from1.01±0.67 to 1.76±0.35 mg kg^{-1}, Silicon content ranged from 0.71±0.04 to 1.07±0.53 mg kg^{-1} and Selenium content ranged from 0.18±0.01 to 0.35±0.08 mg kg^{-1}. Results of the analysis revealed that Temi tea is a good source of essential mineral and trace elements for the human diet.

Key words : Temi tea, Stimulant, Mineral, Trace, ICPMS.

Introduction

Tea is one of the three main non-alcoholic beverages along with coffee and cocoa consumed worldwide and has become a staple part of the human diet and enjoyed by the majority of people (Peng *et al*., 2024). As a non-alcoholic beverage, tea (*Camellia sinensis* L) belonging to family Theaceae is widely consumed by two-thirds of the world's population after water (Banik *et al*., 2019). For centuries, tea has been a popular and healthy beverage all over the world (Liang *et al*., 2021). Over two billion cups of tea made from young tea plant shoots are consumed daily by tea drinkers, demonstrating the beverage's widespread appeal due to its stimulating and therapeutic qualities in addition to its non-alcoholic property (Drew, 2019). For the production of tea, the apical bud and two terminal leaves of the tea crop are harvested. Initially cultivated in Asian countries, the tea plant has long been utilized for traditional medicinal purposes (Makanjuola *et al*., 2020). In addition to its appealing taste and aroma, tea is popular due to its numerous pharmacological advantages, which include reducing the risk of atherosclerosis, preventing cardiovascular diseases, inhibiting the growth of tumour cells and preventing obesity (Shang *et al*., 2021). The majority of these health benefits are derived from various phytochemicals, as tea contains over 700 different compounds, including polysaccharides, flavonoids, vitamins C, E and K, amino acids, and caffeine (Bag *et al*., 2022).

In India, tea is grown in 17 states, with the North-Eastern states accounting for roughly 75% of all tea plantation area (Malakar *et al*., 2022). India produces two varieties of tea: orthodox and CTC (crush, tear and curl), which vary according to the fermentation time (Samynathan *et al*., 2016). Black tea, oolong tea and green tea are examples of fermented, semi-fermented and non-fermented tea products. The biochemical characteristics that impact the quality of black tea are determined by the type of tea leaves that are harvested (Jayaganesh and Venkatesan, 2010). Significant consumption of tea phytochemicals, such as catechins, caffeine, and others, established the biochemical foundation for the benefit, with flavonoids being the most significant of these substances (He *et al*., 2021).

Tea contains over 700 bioactive substances, including alkaloids (theobromine, caffeine), volatile flavor compounds (VFC), various classes of polyphenols and unique amino acid L-theanine (Das *et al*., 2022). Due to its various neuroprotective, thermogenic, anti-carcinogenic, cholesterol-lowering, anti-inflammatory, antioxidant, antimicrobial and anti-hypertensive properties, tea is much more common in the regular human diet (Qi *et al*., 2017). Tea polyphenols, amino acids, rich mineral elements and other healthy components could be supplemented by drinking tea (Peng *et al*., 2017; Karak *et al*., 2017). Additionally, it may lessen mental exhaustion, lower blood cholesterol, prevent the oxidation of low-density lipoproteins, and lower the risk of cancer and cardiovascular disease (Chung *et al*., 2003).

Tea plays a significant factor in terms of human intake of several nutritional trace elements (Karak and Bhagat, 2010). In addition to being a great source of antioxidants, tea is regarded as a good source of essential elements like manganese (Mn), iron (Fe), zinc (Zn), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P) and sulphur (S) (Malik *et al*., 2008). Indian teas are known worldwide for their unique taste and aroma. Temi tea is one of the famous tea brands from India which has high demand in the international market. Temi Tea Garden is the only tea estate in the mountainous state of Sikkim that produces premium organic tea, which is sold under the brand name 'Temi tea' and is in high demand worldwide (Rai and Bag, 2024). The present study was conducted to assess and quantify the level of different mineral and trace elements in the Temi tea sample collected from different flushes.

Materials and Methods

The experiment was conducted at laboratory of Department of Horticulture, Sikkim University, Sikkim, India situated at 28°35'N latitude, 77°12'E longitude and an altitude of 228.6 m above MSL during February-March, 2018. Temi tea samples of different flush were collected season wise (March- November, 2017) from Temi Tea Garden, South Sikkim situated at latitude and longitude of 27.23^{0}N and 88.42^{0}E.

Treatment details

Season/flush	Tea type
1.Spring Flush (T_1)	Green tea
2.Spring Flush (T_2)	Orthodox Black tea
3.Summer Flush (T_3)	Orthodox Black tea
4.Monsoon Flush (T_4)	Orthodox Black tea
5.Autumn Flush (T_5)	Orthodox Black tea

For the multi elemental analysis of the samples, total five number of treatments were taken under completely randomized design with four replications. Multi-elemental analysis was carried out by employing Inductively Coupled Plasma Mass Spectrometry (ICPMS) technique.

Sample Digestion and Multi elemental profiling

In order to achieve a clear and colourless solution, the sample was acid digested in a microwave using a multi-wave digestion system (Anton Par Multi-wave 3000, India) under the following conditions: power: 1200 W; IR: 190 °C; rate: 0.3 bar sec-^{1}; ramp: 5 minutes; hold: 7 minutes with the use of Di-acid solution (concentrated nitric acid and perchloric acid in a ratio of 9:4). 10 ml of the di-acid solution were added to a conical flask (100 ml) containing 0.5 grams of the leaf sample. The sample mixture was kept on hot plate for digestion and was completed by disappearance of red fumes and appearance of white fumes at the bottom of the conical flask. The solution was diluted by adding a small amount of water (5–10 ml) to the conical flask and was then filtered through filter paper and collected in a 50 ml volumetric flask. The volume was made up to the mark with double distilled water. For the multi-elemental analysis in ICPMS, the colourless and transparent solution was kept in the narrow-mouth bottle. Analysis of the sample was carried out by ICPMS (Perkin Elmer, Nex ION 300 X, USA) with cross flow nebulizer. The instrument was calibrated using standard reference material (peach leaves; NIST, 1547). Using a multi-element standards solution, the ionic composition of the digested sample was investigated. Final data in the result are means ± S.D of the replicates.

Results and Discussion

Calcium (Ca)

Calcium keeps tissue strong, flexible and rigid, which enables normal body movement. It also makes up a large portion of the structure of bones and teeth. The Ca content in the present study ranged from 16.80±12.56 to 29.12±6.13 mg kg^{-1} as shown in Table 1. The highest Ca content was found in (T_5) Black tea (Autumn flush) while the lowest Ca content was found in the (T_1) Green tea (Spring flush). Similar studies have been conducted where (Dawodu *et al*., 2013) reported the Ca content of Green and Black Nigerian tea in the range of 7.99±0.081 µg/g and 1.91±0.023 µg/g, respectively while; Lagad *et al*. (2011) have reported the Ca content of Assam, Darjeeling, Munnar and Kangra tea ranged from 5809±1122 µg/g, 5528±1344 µg/g, 21.8±6.6 µg/g and 6074±1349 µg/g respectively, which are lower than the current findings.

Sodium (Na)

Being an essential nutrient sodium is involved in blood pressure regulation, fluid and electrolyte balance, and the maintenance of normal cellular homeostasis (Strazzullo and Leclercq, 2014). WHO recommends less than 2000 mg/day of sodium for adults. The Na content in the present study ranged from 1.65±0.79 to 3.40±1.97 mg kg^{-1} as shown in Table 1. The highest Na content was found in (T_3) Black tea (Summer flush), while the lowest Na content was found in the (T_2) Black tea (Spring flush). Likewise, Lagad *et al*. (2011) have reported the Na content of Munnar Green and Black tea, which ranged from 30.3±8.1 µg/g and 41.5±8.4 µg/g, respectively; while the Na content of Assam, Darjeeling and Kangra tea ranged from 31.1±11.1 µg/g, 18.4±10.1 µg/g and 78.1±1.4 µg/g, respectively; which are lower than the findings of the present study.

Boron (B)

Although the exact significance of boron for humans and animals has not been determined, there is compelling evidence that suggests it is most likely an essential micronutrient (Kot, 2009). It has been shown that the presence of boron positively impacts the composition and function of various body parts, including the human immune system, skeleton and brain (Resano *et al*., 2007). An excessive amount of boron in the body can cause lethargy, nausea, vomiting, and diarrhoea (Zioła-Frankowska *et al*., 2014). According to the World Health Organization, adults can safely consume 1–13 mg of boron per day. The boron content in the present study ranged from 1.01±0.67 to 1.76±0.35 mg kg^{-1} as shown in Table 1. The highest B content was found in (T_5) Black tea (Autumn flush); while the lowest B content was found in the (T_1) Green tea (Spring flush). Similarly, Derun *et al*. (2010) have reported the boron content in black and green tea in the range 0.728 ± 0.055 mg kg^{-1} and 0.544 ± 0.028 mg kg^{-1}, respectively; which are lower than the current findings; while; Zioła-Frankowska *et al*. (2014) have observed the mean total content of boron in the range of 8.31 to 18.40 mg/kg in black teas, which are higher than the current findings.

Silicon (Si)

Silicon is a microelement serves a variety of vital purposes in the human body, including the development and upkeep of healthy osseocartilaginous connective tissue, including skin, hair and nails, as well as the prevention of neurodegenerative and cardiovascular disorders (Sadowska and Œwiderski, 2020). The recommended daily intake of dietary silicon is between 10 and 25 mg, but levels of 25 mg or more appear to be the most effective, at least for maintaining bone health in men and premenopausal women, with no negative side effects (Jugdaohsingh *et al*., 2004). The silicon content in the present study ranged from 0.71±0.04 to 1.07±0.53 mg kg^{-1} as shown in Table 1. The highest Si content was found in T_1 Green tea (Summer flush) while the lowest Si content was found in the T_4 Black tea (Monsoon flush).

Selenium (Se)

Selenium is a crucial metric for assessing the quality of tea (Wu *et al*., 2024). For healthy adults, the World Health Organization advises 60–200 mg of selenium daily, with a maximum acceptable intake of 400 mg. For both humans and animals, selenium (Se) is a necessary trace element that is crucial for immune system function and disease prevention. In humans Selenium (Se) is an anti-oxidative trace element and its deficiency can lead to negative consequences like infertility, thyroid issues, and cognitive decline (Chen *et al*., 2022). Selenium has a variety of biological protective effects in the human body including endocrine system protection, carcinogenesis inhibition, reproductive function promotion, and cell membrane and body immunity stability (Pecoraco *et al*., 2022; Yang *et al*., 2022). Drinking tea is regarded as a significant source of selenium. The Se content in the present study ranged from 0.18±0.01 to 0.35±0.08 mg kg^{-1} as shown in Table 1. The highest Se content was found in (T_5) Black tea (Autumn flush); while the lowest Se content was found in the T_4 Black tea (Monsoon

Table 1 : Multi-elemental concentration in Temi tea samples (mg kg^{-1}).

Treatment	Ca	Na	B	Si	Se
T_1	16.80±12.56	3.22±0.22	1.01±0.67	1.07±0.53	0.22±0.15
T_2	22.97±6.12	1.65±0.79	1.49±0.52	0.83±0.04	0.28±0.09
T_3	25.50±1.61	3.40±1.97	1.55±0.22	0.85±0.03	0.31±0.02
T_4	18.44±5.62	2.15±0.87	1.70±0.63	0.71±0.04	0.18±0.01
T_5	29.12±6.13	2.83±0.42	1.76±0.35	0.72±0.03	0.35±0.08

flush). Similarly; Wang (1998) have reported the Se content for 133 tea samples which varied from 0.021 to 0.774 mg kg^{-1} with a minimum value of 0.017 mg kg^{-1} and Wu *et al*. (2024) have reported the selenium content in old leaves ranged from 0.29 to 2.73 mg kg^{-1} which are higher than the current findings.

Conclusion

The variation in the climate during the growing season and the different processing methods used to make black and green tea are the reason for the variation in the elemental content among the various flushes of Temi tea. The result of the study showed that the Temi tea was comparable to other high-quality teas from various origins in terms of elemental concentration and contained sufficient amounts of vital mineral and trace elements. Results of the analysis revealed that Temi tea is a good source of essential mineral and trace elements for the human diet.

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