Multi-elemental Profiling of Temi Tea (*Camellia sinensis*) from Sikkim by ICPMS

Guddu Rai

Department of Horticulture, Sikkim University, Gangtok-737 102, India
E-mail: guddurai94@gmail.com

Abstract: The experiment was conducted at Sikkim University, Sikkim, India, to quantify the level of multi-elements in different flushes samples of Temi tea (*Camellia sinensis*) which is a renowned organic tea brand grown in the state of Sikkim through ICPMS. In this study the content of copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb), cobalt (Co) and aluminium (Al) were analyzed through ICPMS. In Temi tea lead content ranged from 0.18 to 0.26 mg kg^{-1} and cadmium from 0.01 to 0.04 mg kg^{-1} respectively which were below the permissible limit in all the flushes. Other elements were found in good quantity in all the flushes of Temi tea where the copper, zinc, cobalt and aluminium content ranged from 19.69 to 33.74, 0.73 to 1.30, 0.16 to 0.39 and 108.53 to 176.26 mg kg^{-1} respectively and were below the permissible limit.

Keywords: Temi tea, *Camellia sinensis,* multi-elements, ICPMS

Tea is one of the most widely consumed popular beverage in the world (Klepacka et al., 2021) and has become a vital part of human diet (Peng et al., 2024). It has been a staple drink in many countries (Yang et al., 2014) and almost 3 billion people drink tea in more than 160 countries worldwide (Luo et al., 2024). The variety of tea leaves, the conditions of cultivation, harvest and the processing techniques all play a major role in determining these characteristics (Horie et al., 2017, Wu et al., 2018). Of the several steps in the production of tea (leaf handling, withering, rolling, drying, and sorting), fermentation (oxidation) is one of the most crucial (Qu et al., 2019). Black tea is the most popular due to its sensory qualities, but interest in green tea has also been growing for a long time (Yu et al., 2019).

The healthy development of the tea plant and the resulting tea quality as well as the positive health benefits are significantly influenced by the mineral elements and polyphenolic compounds present in the tea leaves (Peng et al., 2022, Tolra et al., 2020). Mineral element accumulation is a concern for both tea producers and consumers (Zhang et al., 2018). The existence of trace elements in tea results from tea plants typically being cultivated in soils that are highly acidic in which trace elements may be more bioavailable for absorption by the roots (Karak and Bhagat 2010). Trace element levels in tea can result in both positive and negative impacts on human health (Atasoy et al., 2019). Minerals, trace elements, and flavonoids are all present in tea and are vital to human health (Thao and Mai 2017).

Tea's high antioxidant activity, which is mostly caused by the presence of phenolic compounds—tannins, catechins and their derivatives is the main factor contributing to beneficial effect on human health (Pinto et al., 2020). The primary active ingredient of tea is catechins which make up 70% of its polyphenols (Yan et al., 2020, Khan et al., 2023). The primary tea polyphenols in black tea are thearubigins and theaflavins (Ke et al., 2021). During tea processing, catechins are oxidized to produce theaflavins (TF), which undergoes enzyme-catalyzed reactions to further transform into thearubigins (TR) (Das et al., 2019). Taste, strength, color, and overall quality of black tea are all greatly impacted by the presence of TF and TR and their ratio (Rahman et al., 2020). Epicatechin, epigallocatechin, epicatechin gallate, and epigallocatechin gallate are the primary monomeric forms of catechins found in green tea (Zagula et al., 2017). Polyphenols (catechins and flavonoids), alkaloids (caffeine, theobromine, theophylline, etc.), volatile compounds, polysaccharides, amino acids, lipids, and vitamins are among the biochemical components of tea leaves that exhibit a range of bioactivities (Arachchi et al., 2019). Indian teas are well known worldwide for their unique aroma and taste (Rai 2025). Temi tea is a top-notch organic tea brand which has a huge demand in the international market and is well known for its top-grade tea leaves (Rai and Bag 2024). So far multi elemental study on Temi tea has not been done till date. Considering these facts, the present study focused on the study multi-elemental profiling of Temi tea (*Camellia sinensis*) samples from Sikkim.

MATERIAL AND METHODS

Tea samples of different flush were collected season wise i.e., from Zaid to rabi season (March- November, 2017) from Temi Tea Garden, South Sikkim situated at latitude and longitude of 27.23^{0}N and 88.42^{0}E. The experiment was conducted at Sikkim University, Sikkim, India during

February- March, 2018.

Treatment details: For the multi elemental analysis of the samples, there were five treatments from two types of Temi tea (green tea and orthodox black tea) collected across four season (spring, summer, monsoon and autumn) in 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: Sample was acid digested in microwave digestion with multi-wave digestion system (Anton Par Multi-wave 3000, India) as per following conditions viz. power- 1200 W; IR - 190 ºC; rate- 0.3 bar sec^{-1}; ramp- 5 minutes; hold – 7 minutes to achieve a clear and colorless solution with the use of Di-acid solution (concentrated Nitric acid and Perchloric acid in the ratio of 9:4). 0.5 g of the leaf sample was taken in the conical flask (100 ml) and 10 ml of Di-acid solution was poured in. 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. Little amount of water (5-10 ml) was poured in the conical flask for the dilution of the solution and filtered through filter paper and collected in a 50 ml volumetric flask. The volume was made up to the mark with double distilled water. The clear and colorless solution was stored in the narrow mouth bottle for the multi-elemental analysis in ICPMS. Analysis of the sample was carried out by ICPMS (Perkin Elmer, Nex ION 300 X, USA) with cross flow nebulizer. Standard reference material (peach leaves; NIST, 1547) was used to calibrate the instrument. The ionic composition of the digested sample was examined using a multi-element standards solution.

RESULTS AND DISCUSSION

Copper (Cu): The Cu content in the processed Temi tea samples of different flush ranged from 19.69 to 33.74 mg kg^{-1} (Table 1) which is below the PFA (Prevention of Food Adulteration Act, 1954, India) limit of 150 mg kg^{-1} (Seenivasan et al., 2008) and also below the limits set by the US (150 mg kg^{-1}) (Ning et al., 2011) and Japanese regulations (100 mg kg^{-1}) (Zhong et al., 2016). The highest Cu content was in the green tea (spring flush) while the lowest in black tea (-monsoon flush). Podwika et al. (2018) observed copper concentration in the range of 9.1 to 32.7 mg kg^{-1}. Street et al. (2006) reported Cu content in the range of 9-65 mg kg^{-1} and Zhong et al. (2016) in the range 7.73-63.71 mg kg^{-1}which was higher than the present findings. Seenivasan et al. (2008) reported the *Cu* content ranged between 15.9 and 32.2 mg kg^{-1} in South Indian black tea. The present findings also showed higher value than those reported in Iranian tea where the *Cu* content ranged from 24.30 to 32.60 mg kg^{-1}

(Abdolmaleki 2016). Herman et al. (2022) in green tea observed Cu content in range of 11.7–18.6 µgg^{-1} in green tea and Koch et al., (2018) in green teas originating from different countries (China, India, Japan, Kenia, and Sri Lanka) in range of 1.34-2.03 mg 100 g^{-1}.

Zinc (Zn): The Zn content in the processed Temi tea samples of different flush ranged from 0.73 to 1.30mg kg^{-1} (Table 1). The highest Zn content was in the black tea (spring flush) while the lowest in black tea (autumn flush). Podwika et al. (2018) reported zinc concentration in the range between 12.6 to 45.5 mg kg^{-1} which are higher than the present findings. Sultana et al., (2023) observed that zinc content of Bangladeshi black tea and green tea in the range 21.58 µg g^{-1} and 5.13 µg g^{-1} respectively and Dawodu et al. (2013) in Nigerian green and black tea 21.17 µg g^{-1} and 30.66 µg g^{-1} respectively. Lahiji et al. (2013) in Iranian tea sample in the range of 38.21 µg g^{-1}, Samali et al. (2012) in Nigerian herbal tea in the range 1.11 to 9.73 µg g^{-1} and Koch et al., (2018) in green teas originating from different countries (China, India, Japan, Kenia, and Sri Lanka) in the range 3.11–4.07 mg 100 g^{-1}.

Cadmium (Cd): The Cd content in the processed Temi tea samples of different flush ranged from 0.01to 0.04 mg kg^{-1} (Table 1). The highest Cd content was in green tea (spring flush) while the lowest in black tea (monsoon flush). Lisia et al. (2015) reported Cd content in Brazilian tea in the range 0.02 to 0.09 mg kg^{-} Rashid et al. (2016) in Bangladeshi in fresh and processed tea reported in the range 0.03-0.13 µg g^{-1} and 0.04-0.16 µg g^{-1} respectively. Zhong et al. (2016) in Chinese tea reported the range of 0.01 to 0.39 mg kg^{-1} and Seenivasan et al. (2008) in the range between 0.05 to 0.38 mg kg^{-1} in South Indian black tea which was higher than the current findings. Zazouli et al. (2010) in Iranian tea was in range 0.09 to 1.92 µg g^{-1}.

Lead (Pb): The Pb content in the Temi tea sample of different flush ranged from 0.18 to 0.26 mg kg^{-1} (Table 1) which is below the PFA limit of 10 mg kg $^{-1}$ (Seenivasan et al., 2008). The highest Pb content was in black tea (autumn flush) while the lowest was in black tea (spring flush). Abdolmaleki (2016) reported Pb content in Iranian black tea samples in the range 0.22 to 0.35 mg kg^{-1} which are higher than the present findings. Lagad et al., (2012) specified individual Pb content of Assam tea, Kangra tea, Darjeeling tea and Munnar tea as 614 ng g^{-1}, 877 ng g^{-1}, 630 ng g^{-1} and 479 ng g^{-1} respectively. Soliman (2016) reported concentration of lead in commercial Egyptian black tea sample was in the range 0.29 to 3.2 µg g^{-1} and Sultana et al. (2023) of Bangladeshi black and green tea in the range 1.39 µg g^{-1} and 3.61 µg g^{-1}respectively. Srividhya et al. (2011) reported in the range 2.31 mg kg^{-1} in tea from South India and Zazouli et al. (2010) in Iranian tea in the range 0.66 to 15.48 µg g^{1} respectively.

Table 1. Levels of multielement in Temi tea samples (mg kg^{-1})

Treatment		Multielement (Mean ± SD)					
		Cu	Zn	Cd	Pb	Co	Al
Spring flush	Green tea	33.74±24.49	1.10±0.80	0.04±0.01	0.25±0.05	0.39±0.05	128.46±103.6
Spring flush	Orthodox black tea	28.15±6.56	1.30±0.39	0.03±0.01	0.18±0.19	0.16±0.06	150.04±37.45
Summer flush	Orthodox black tea	25.50±1.43	1.04±0.09	0.03±0.03	0.24±0.04	0.28±0.05	176.26±20.67
Monsoon flush	Orthodox black tea	19.69±5.55	0.73±0.09	0.01±0.02	0.21±0.08	0.16±0.11	108.53±32.30
Autumn flush	Orthodox black tea	22.32±4.10	0.73±0.12	0.02±0.02	0.26±0.04	0.26±0.06	157.04±30.39

Cobalt (Co): The Co content in the Temi tea samples of different flush ranged from 0.16 to 0.39 mg kg^{-1} (Table 1). The highest Co content was in green tea (spring flush) while the lowest in black tea (spring flush). The findings from the study regarding the cobalt content of tea leaves were in line with previous research where quantities of this element have been observed to be less than 1 mg kg^{-1} in general (Shen and Chen 2008). Lisia et al. (2015) reported the Co content of Brazilian tea in the range 0.19 to 0.38 mg kg^{-1}, Narin et al. (2004) in black tea from Turkey in the range of 7.7 to 30.2 µg g^{-1} and Rohilla et al. (2021) of black tea leaves (tea brew) of Indian market in the range of 71.9-214.3 µg kg^{-1}. Girolametti et al. (2023) observed Co content in black and green teas from tea gardens in six different European countries in the range 0.007 to 0.581 mg kg^{-1} which is higher than the present findings.

Aluminium (Al): The Al content in the Temi tea samples of different flush ranged from 108.53 to 176.26 mg kg^{-1} (Table 1). The highest Al content was in black tea (summer flush) and the lowest in black tea (monsoon flush). The variation of Al content in the present study could be attributed to type of tea, processing technique used and fluctuations in the climatic conditions throughout the growth period. Lahiji et al. (2013) reported Al content of Iranian tea in the range 0.741 ± 0.14 mg g^{-1} and Lagad et al. (2011) specified the Al content of Munnar green and black tea in the range 840 µg g^{-1} and 1367 µg g^{-1} respectively. Ozdemir et al. (2022) reported for black teas produced in Rize, Tabzon and Giresun/Turkey in the range 8177.75 to 15657.72 mg kg^{-1} and Girolametti et al. (2023) Al content in black and green teas in the range 733 mg kg^{-1} to 4865 mg kg^{-1} which is higher than the present findings. A concentration of 40-200 mg kg^{-1} dry weight of aluminium is said to be toxic to crops (White and Brown 2010). Young tea leaves (on an average 380 mg Al kg^{-1} dw) and old tea leaves (on an average 6800 mg Al kg^{-1} dw) both surpass these values (Carr et al., 2003) without exhibiting any signs of toxicity (Pongrac et al., 2020). Al is known to be found in greater amount in tea leaves than in other herbal plants, which hardly ever exhibit concentrations above 1000 mg kg^{-1} (Chizzola 2012).

CONCLUSION

The variation in the elemental content across the different flushes of Temi tea can be attributed to the fluctuations in the climatic conditions throughout the growing period and the different processing method used for making green and black tea. Temi tea had adequate amounts of essential dietary nutrients and was comparable to other premium teas of different origins in terms of elemental concentration.

REFERENCES

Abdolmaleki F 2016. Chemical analysis and characteristics of black tea produced in North of Iran. *Journal of Food Sciences and Biotechnology* **6**(1): 23-32.

Arachchi JDK, Gunasekare MTK and Ranatunga MAB 2019. Biochemical diversity of global tea [*Camellia sinensis* (L.) O. Kuntze] germplasm and its exploitation: A review. *Genetic Resources and Crop Evolution* **66**(1): 259-273.

Atasoy AD, Yesilnacar MI, Yildirim A and Atasoy AF 2019. Nutritional minerals and heavy metals in tea infusions and daily intake of human body. *Turkish Journal of Agriculture-Food Science and Technology* **7**(2): 234-239.

Carr H, Lombi E, Küpper H, Mcgrath S and Wong M 2003. Accumulation and distribution of aluminium and other elements in tea (*Camellia sinensis*) leaves. *Agronomie* **23**(8): 705-710.

Chizzola R 2012. Metallic mineral elements and heavy metals in medicinal plants. *Medicinal and Aromatic Plant Science and Biotechnology* **6**(1): 39-53.

Das S, Samanta T and Datta AK 2019. Analysis and modeling of major polyphenols during oxidation in production of black tea. *Journal of Food Processing and Preservation* **43**(12): e14283.

Dawodu MO, Obimakinde S and Olutana GO 2013. Trace metal concentrations in some tea leaves consumed in Ibadan, Nigeria. *African Journal of Agricultural Research* **8**(46): 5771-5775.

Girolametti F, Annibaldi A, Illuminati S, Damiani E, Carloni P and Truzzi C 2023. Essential and potentially toxic elements (PTEs) content in European tea (*Camellia sinensis*) leaves: Risk assessment for consumers. *Molecules* **28**(9): 3802. doi: 10.3390/molecules28093802.

Herman M, Janiak MA, Sadlik JK, Piekoszewski W and Amarowicz R 2022. Iron, zinc, copper, manganese and chromium in green teas, their transfer to extracts and correlations between contents of elements and bioactive compounds. *Polish Journal of Food and Nutrition Sciences* **72**(4): 421-429.

Horie M, Nara K, Sugino S, Umeno A and Yoshida Y 2017. Comparison of antioxidant activities among four kinds of Japanese traditional fermented tea. *Food Science & Nutrition* **5**(3): 639-645.

Karak T and Bhagat RM 2010. Trace elements in tea leaves, made tea and tea infusion: a review. *Food Research International* **43**(9): 2234-2252.

Ke L, Xu W, Gao J, Gao G, Wang H, Zhou J, Liu J, Rao O and Xu Y 2021. Isolation and characterization of thermo-tolerant polyphenol oxidases in a black tea infusion. *Food Control* **119**: 107465.

Khan MRM, Islam MA, Uddin R, Kalam MA, Baishakh NN, Barua P, Talukder MHR and Ahmad I 2023. Biochemical investigation of Bangladeshi black tea and their correlation to organoleptic quality evaluation. *Heliyon* **9**: 1-8.

Klepacka J, Tońska E, Rafałowski R, Czarnowska-Kujawska M and Opara B 2021. Tea as a source of biologically active compounds in the human diet. *Molecules* **26**(5): 1487. doi: 10.3390/molecules26051487

Koch W, Kukula-Koch W, Komsta Ł, Marzec Z, Szwerc W and Głowniak K 2018. Green tea quality evaluation based on its catechins and metals composition in combination with chemometric analysis. *Molecules* **23**(7): 1689. doi: 10.3390/molecules23071689.

Lagad RA, Alamelu D, Gurav T, Pande K and Aggarwal SK 2011. Elemental Profiling of Indian Tea by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). *Atomic Spectroscopy* **32**(4): 168-174.

Lagad RA, Alamelu D, Chaudhary AK and Aggarwal SK 2012. Determination of heavy metals and lanthanides in indian tea by inductively coupled plasma mass spectrometry (ICP-MS). *Atomic Spectroscopy* **33**(4): 109-116.

Lahiji N, Tadayon F, Tamiji F and Lahiji AH 2013. Mineral analysis the infusion of black tea samples by atomic absorption spectrometry. *In E3S Web of Conferences* 1: 39006. DOI: 10.1051/e3sconf/20130139006

Lisia M, Priscila DUBOC, Jaylei MG and Silvana CJ 2015. Determination of arsenic, cadmium and lead concentration in teas, commercialized in Rio De Janeiro, Brazil, and their transfer to tea infusion. *Journal of Mathematics* **2015**: 179-186.

Luo Q, Luo L, Zhao J, Wang Y and Luo H 2024. Biological potential and mechanisms of Tea's bioactive compounds: An Updated review. *Journal of Advanced Research* **65**: 345-363.

Narin I, Colak H, Turkoglu O, Soylak M and Dogan M 2004. Heavy metals in black tea samples produced in Turkey. *Bulletin of Environmental Contamination & Toxicology* **72**: 844-849.

Ning P, Gong C, Zhang Y, Guo K and Bai J 2011. Lead, cadmium, arsenic, mercury and copper levels in Chinese Yunnan Pu'er tea. *Food Additives and Contaminants* **4**(1): 28-33.

Ozdemir Z, Zannou O and Koca I 2022. Assessment of the aluminium contents of black tea and black tea infusions. *Discover Food* **2**(1): 13.

Peng Y, Jin T, Yang R, Chen R and Wang J 2022. Distribution of mineral elements in the soil and in tea plants (*Camellia sinensis*). *Journal of Elementology* **27**(3): 765-796.

Peng Y, Song H, Jin T, Yang R and Shi J 2024. Distribution characteristics of potentially toxic metal (loid) s in the soil and in tea plant (Camellia sinensis). *Scientific Reports* **14**(1): 14741. DOI: 10.1038/s41598-024-65674-1

Pinto G, Illiano A, Carpentieri A, Spinelli M, Melchiorre C, Fontanarosa C, di Serio M and Amoresano A 2020. Quantification of polyphenols and metals in Chinese tea infusions by mass spectrometry. *Foods* **9**(6): 835. https://doi.org/10.3390/foods9060835

Podwika W, Kleszcz K, Krośniak M and Zagrodzki P 2018. Copper, manganese, zinc, and cadmium in tea leaves of different types and origin. *Biological Trace Element Research* **183**: 389–395.

Pongrac P, Tolra R, Hajiboland R, Vogel-Mikuš K, Kelemen M, Vavpetič P, Pelicon P, Barcelo J, Regvar M and Poschenrieder C 2020. Contrasting allocation of magnesium, calcium and manganese in leaves of tea (*Camellia sinensis* (L.) Kuntze) plants may explain their different extraction efficiency into tea. *Food and Chemical Toxicology* **135**: 110974. https://doi.org/10.1016/j.fct.2019.110974

Qu F, Zhu X, Ai Z, Ai Y, Qiu F and Ni D 2019. Effect of different drying methods on the sensory quality and chemical components of black tea. *LWT* **99**: 112-118.

Rahman MM, Hossain MM, Das R and Ahmad I 2020. Changes in phytochemicals and determination of optimum fermentation time during black tea manufacturing. *Journal of Scientific Research* **12**(4): 657-664.

Rai G and Bag N 2024. Biochemical characterization of Temi Tea from Sikkim. *Environment and Ecology* **42**(2B): 910-914.

Rai 2025. Determination of mineral and trace elements in Temi tea (*Camellia sinensis*) samples from Sikkim, India. *Plant Archives* **25**(1): 86-90.

Rashid MH, Fardous Z, Chowdury MAZ, Alam MK, Bari ML, Moniruzzaman M and Gan SH 2016. Determination of heavy metals in the soils of tea plantations and in fresh and processed tea leaves: an evaluation of six digestion methods. *Chemistry Central Journal* **10**(1): 1-13.

Rohilla V, Kathait GS, Biswas D, Thapliyal P and Ruhela B 2021. Estimation of heavy metals in some Indian black tea leaves by inductively coupled plasma mass spectrometer (ICP-MS) and associated health risks. *Indian Journal of Agricultural Research* **55**(2): 181-186.

Samali A, Kirim RA and Mustapha KB 2012. Qualitative and quantitative evaluation of some herbal teas commonly consumed in Nigeria. *African Journal of Pharmacy and Pharmacology* **6**(6): 384-388.

Seenivasan S, Manikandan N, Muraleedharan NN and Selvasundaram R 2008. Heavy metal content of black teas from South India. *Food Control* **19**: 746-749.

Shen FM and Chen HW 2008. Element composition of tea leaves and tea infusions and its impact on health. *Bulletin of environmental contamination and toxicology* **80**: 300-304.

Soliman NF 2016. Metals contents in black tea and evaluation of potential human health risks to consumers. *Health Economics and Outcome Research Open Access* **2**(1): 1-4.

Srividhya B, Subramanian R and Raj V 2011. Determination of lead, manganese, copper, zinc, cadmium, nickel and chromium in tea leaves. *International Journal of Pharmacy and Pharmaceutical Sciences* **3**(4): 257-258.

Sultana S, Ahmed FT, Rahman N and Alam MF 2023. Determination of Ni, Cu, Cd, Zn, Pb, Cr and Mn in some black and green tea leaves and their infusions available in Bangladeshi local markets. *Applied Chemical Engineering* **6**(1): 28-37.

Street R, Szakova J, Drabek O and Mladkova L 2006. The status of micronutrients (Cu, Fe, Mn, Zn) in tea and tea infusions in selected samples imported to the Czech Republic. *Czech Journal of Food Science* **24**(2): 62-71.

Thao NT and Mai TT 2017. Determination of metal content in tea leaves grown in yen bai and tuyen quang province, Vietnam. *Vietnam Journal of Science and Technology* **55**(5A): 143-150.

Tolrà R, Martos S, Hajiboland R and Poschenrieder C 2020. Aluminium alters mineral composition and polyphenol metabolism in leaves of tea plants (*Camellia sinensis*). *Journal of Inorganic Biochemistry* **204**: 110956. DOI: 10.1016/j.jinorgbio.2019.110956

White PJ and Brown P 2010. Plant nutrition for sustainable development and global health. *Annals of botany* **105**(7): 1073-1080.

Wu X, Yang J and Wang S 2018. Tea category identification based on optimal wavelet entropy and weighted k-nearest neighbors algorithm. *Multimedia Tools and Applications* **77**(3): 3745-3759.

Yan Z, Zhong Y, Duan Y, Chen Q and Li F 2020. Antioxidant mechanism of tea polyphenols and its impact on health benefits. *Animal Nutrition* **6**(2): 115-123.

Yang CS, Chen G and Wu Q 2014. Recent scientific studies of a traditional Chinese medicine, tea, on prevention of chronic diseases. *Journal of Traditional and Complementary Medicine* **4**(1): 17-23.

Yu S, Zhu L, Wang K, Yan Y, He J and Ren Y 2019. Green tea consumption and risk of breast cancer: A systematic review and updated meta-analysis of case-control studies. *Medicine* **98**(27): e16147.

Zaguła G, Bajcar M, Saletnik B, Czernicka M, Puchalski C, Kapusta I and Oszmiański J 2017. Comparison of the effectiveness of water-based extraction of substances from dry tea leaves with the use of magnetic field assisted extraction techniques. *Molecules* **22**(10): 1656.

Zazouli MA, Bandpei AM, Maleki A, Saberian M and Izanloo H 2010. Determination of cadmium and lead contents in black tea and tea liquor from Iran. *Asian Journal of Chemistry* **22**(2): 1387.

Zhang J, Yang R, Chen R, Peng Y, Wen X and Gao L 2018. Accumulation of heavy metals in tea leaves and potential health risk assessment: a case study from Puan County, Guizhou Province, China. *International Journal of Environmental Research and Public Health* **15**(1): 133.

Zhong WS, Ren T and Zhao LJ 2016. Determination of Pb (Lead), Cd (Cadmium), Cr (Chromium), Cu (Copper), and Ni (Nickel) in Chinese tea with high-resolution continuum source graphite furnace atomic absorption spectrometry. *Journal of Food and Drug Analysis* **24**: 46-55.