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# GEOGRAPHIC AUTHENTICATION OF CEYLON TEA BASED ON THE TRACE ELEMENT AND STABLE ISOTOPE FINGERPRINTS

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Tea (*Camellia sinensis*) is the most commercially important agricultural export in Sri Lanka. Ceylon tea is renowned for its unique taste, rich golden colour, and fresh aroma. However, it is one of the most common targets for food counterfeiting, which poses a significant risk to consumers due to its increasing popularity and widespread consumption. This study aims to investigate whether a chemometric model based on stable isotope ratios and trace elements can differentiate Ceylon tea from teas of other major tea-exporting countries. A total of 298 orthodox black tea samples: 12 from China, 20 from India, 16 from Vietnam, 16 from Kenya, and 234 from Sri Lanka, representing all the seven tea growing regions were collected. The stable isotope composition ($\delta^{13}C$, $\delta^{15}N$, $\delta^{2}H$, and $\delta^{18}O$) and the concentrations of 18 trace elements (Al, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Ga, K, Mg, Mn, Ni, Rb, Sr, V and Zn) were determined using isotope ratio mass spectrometry (IRMS) and inductively coupled plasma mass spectrometry (ICP-MS), respectively. Unsupervised principal component analysis was followed by supervised orthogonal partial least square discriminant analysis (OPLS-DA) to differentiate Ceylon tea from other tea. While an overlap between Sri Lankan and Indian tea was observed, the OPLS-DA score plot demonstrated good overall separation of Ceylon tea from others, supported by strong $R^2$ and $Q^2$ values (0.816 and 0.789, respectively). Eight variables ($\delta^{2}H$, $\delta^{18}O$, $\delta^{13}C$, Rb, As, Sr, Cr, and Co) were identified as significant indicators, and these findings are consistent with existing studies. External validation using a test dataset of 156 samples yielded a perfect classification accuracy of 100%. This study demonstrates that the use of stable isotope ratios and trace element profiles along with chemometric techniques, provides a robust and reliable approach to differentiate Ceylon tea from others.

**Keywords:** Ceylon tea, Chemometric model, Geographic authentication, Stable isotope ratio, Trace elements