Elemental Mapping of Plant Leaves Using Laser Ablation-Inductively Plasma-Mass Spectrometry (LA-ICP-MS) Technology

Introduction

The presence of essential and toxic elements in edible plant leaves is a growing concern in the context of global food safety and human health. While elements such as manganese, copper, zinc, and phosphorus are vital for human nutrition, excessive intake can lead to health issues. Even more critically, trace amounts of toxic elements—like arsenic, cadmium, lead, and mercury—can pose serious health risks.

To address this challenge, we leverage **Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS)**, a cutting-edge technology that provides high-resolution imaging of elemental distribution directly within solid plant tissues. This powerful technique enables spatially-resolved analysis with exceptional sensitivity, accuracy, and speed—without the need for complex sample preparation.

By visualizing how essential and toxic elements are distributed across plant tissues, LA-ICP-MS offers valuable insights that can inform growing practices, harvesting decisions, and post-harvest processing—ultimately helping to reduce harmful contaminants in the food chain.

In this initiative, we showcase elemental **mapping of key nutrients and toxic metals (Mn, Ni, Cu, Zn, P, As, Cd, Pb, Hg) in bay and basil leaves**, demonstrating how advanced analytical tools can drive innovation in food quality monitoring and consumer health protection.

Materials and Methods

Instrumentation

Elemental imaging was conducted using a **Teledyne Iridia 193 nm excimer laser system** equipped with a **Cobalt ablation cell**, coupled to an **Agilent 8800 ICP-QQQ-MS**. Elemental distribution maps were processed and visualized using **HDIP software v1.8.5.148** (Teledyne Photon Machines, US.

Results

Bay Leaves

Figures 1 and 2 display the spatial distribution of **arsenic (As), lead (Pb), phosphorus (P), manganese (Mn), nickel (Ni), copper (Cu), and zinc (Zn)** in bay leaf tissues, as revealed by LA-ICP-MS imaging.

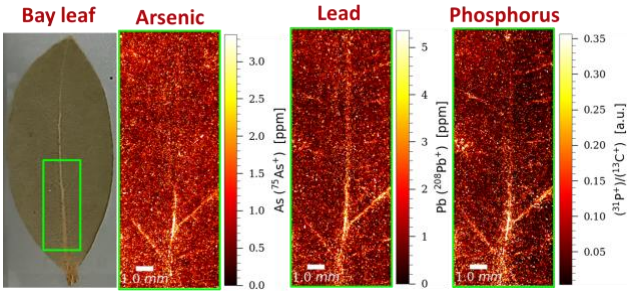

Figure 1. LA-ICP-MS elemental distribution maps of arsenic, lead, phosphorus, manganese, nickel, copper, and zinc in bay leaves.

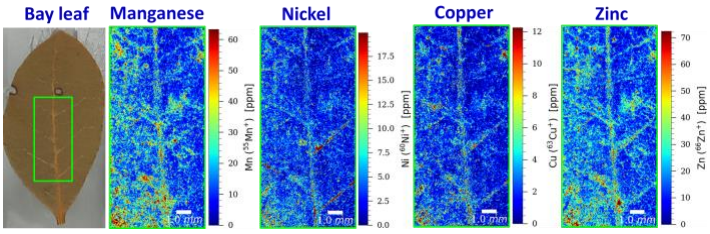

Figure 2. LA-ICP-MS elemental distribution maps of manganese (Mn), nickel (Ni), copper (Cu), and zinc (Zn) in a bay leaf.

Basil Leaves

Figure 3 presents LA-ICP-MS images showing the spatial distribution of **lead (Pb) and phosphorus (P)** in basil leaves.

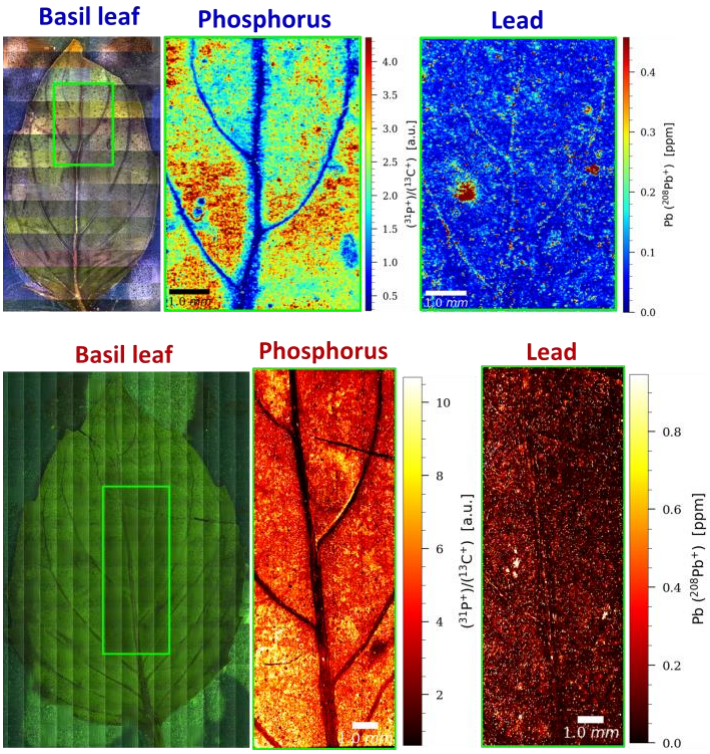

Figure 3. LA-ICP-MS elemental distribution maps of lead and phosphorus in basil leaves.

Visualizing Toxic Element Uptake in Basil Leaves

To demonstrate the distribution of toxic elements in basil leaves, the plants were exposed to water spiked with arsenic (1 ppm), cadmium (10 ppm), and mercury (10 ppm) over a 24-hour period. High-resolution LA-ICP-MS imaging technique captured the spatial distribution of **arsenic, cadmium, and mercury** within the contaminated leaves, as illustrated in Figure 4. These images provide clear insight into elemental uptake and localization in plant tissue.

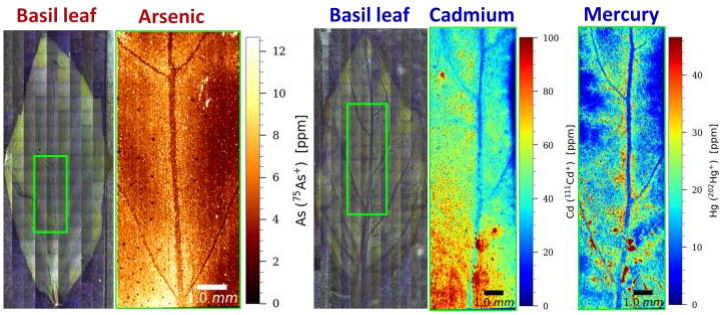

Figure 4. LA-ICP-MS elemental distribution maps of arsenic (As), cadmium (Cd), and mercury (Hg) in contaminated basil leaves.

References

1. Limbeck, A., Galler, P., Bonta, M., Bauer, G., Nischkauer, W., Vanhaecke, F., (2015). Anal. Bioanal. Chem. 407, 6593–6617.
2. Šala, M., Šelih, V. S., & van Elteren, J. T. (2017). Analyst, 142(18), 3356-3359.