



Figure 3 Natural Environment and Honey Source Crops of the Base of Hangzhou Linan Hongjian Bee Breeding Family Farm (Left: Environment; Middle: Honey Harvesting; Right: Honey Source Crop Loquat) (Photo by Hongjian Chen)

### 7.3 Analysis of results and identification of key environmental influencing factors

Multivariate statistics are central to disentangling which environmental factors most strongly shape regional honey quality. Principal component analysis and clustering applied to large elemental datasets have successfully discriminated honeys by geographical origin, with the first two principal components often explaining most of the variance and separating samples into groups that correspond to specific regions or pollution histories (Bora et al., 2024). In such analyses, high loadings for elements like K, Mg, Mn, Cu or Pb highlight combined influences of soil geochemistry, agricultural practices and industrial emissions, while dendrograms based on metal profiles frequently align with known regional boundaries or land-use types (Shakoory et al., 2023).

Case studies from polluted agro-industrial landscapes further illustrate how altitude, distance to emission sources and land-use pattern emerge as key predictors of contaminant levels in honey. Spatial analyses linking Pb, Cd, Cu and Zn concentrations to former industrial facilities show clear gradients, with higher burdens near emission hotspots and evidence for atmospheric transport effects at elevated sites (Shakoory et al., 2023). Comparative work across urban centers and agricultural islands using Pb isotopes indicates that sampling resolution (city vs. regional vs. global) determines whether local infrastructure, agricultural operations or the legacy of leaded gasoline dominates the signal recorded in honey (Awolu et al., 2025). By integrating these chemometric and spatial findings, regional case studies identify a small set of critical environmental drivers-geology and soil, industrial and traffic emissions, climate and altitude-that must be considered when interpreting honey quality differences and designing targeted monitoring and regulatory measures.

## 8 Conclusion and Outlook

Current research converges on the view that honey quality emerges from the interaction of environment, colony management, and processing, rather than any single factor. Reviews emphasize that climate, floral and geographical origin, pollution, hive health, and processing/storage jointly determine physicochemical traits, contaminant loads, and functional properties such as antioxidant and antimicrobial activity. Environmental degradation, intensive agriculture, and improper storage or adulteration add new pressures, but the same studies