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Electronic Nose Protocol for Authentication of Coffee and Tea

A Critical Review of Biomimetic Sensor-Array Technology for Food Authenticity Assurance

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Abstract

Coffee and tea are among the most traded and most frequently adulterated agricultural commodities, and their authentication (by species, geographical origin, processing method, and freshness) remains a persistent analytical challenge. This chapter critically examines the electronic nose (e-nose) as a rapidly available, non-destructive protocol for authenticating coffee and tea against adulteration, mislabelling, and quality fraud. It begins by locating the e-nose in the theoretical framework of biomimetic olfaction and multivariate chemometrics, before reviewing a decade of empirical studies applying metal-oxide-semiconductor sensor arrays, pattern recognition algorithms, and machine learning to distinguish coffee varieties, roast levels, and adulterants, and to distinguish tea origins, storage times, and qualities. A generalized protocol (headspace sampling, sensor-array acquisition, chemometric preprocessing, and classification/regression modelling) is presented and evaluated against confirmatory techniques such as gas chromatography–mass spectrometry. The chapter argues that, although e-nose systems routinely achieve high classification accuracies in controlled studies, sensor drift, limited standardization, and restricted

transferability impede their adoption to routine regulatory practice. Implications for quality assurance, consumer protection, and policy are discussed, and priority areas for future research identified.

Keywords: electronic nose; food authentication; coffee adulteration; tea origin; chemometrics; machine learning

1. Introduction

1.1 Background

Coffee (Coffea arabica L. and Coffea canephora Pierre ex Froehner) and tea (Camellia sinensis (L.) Kuntze) are, after water, the most widely consumed beverages in the world, the commercial value of which is closely tied to claims about botanical species, geographical origin, processing method, and grade. These claims, however, notoriously difficult to verify solely through sensory inspection. Coffee fraud often involves the substitution of lower-value Robusta for Arabica beans, and the addition of cheap fillers such as roasted maize, soybean, barley, or wheat flour to ground coffee, as well as mislabelling of specialty or single-origin coffees (including the extremely high-value kopi luwak, civet coffee) (Ongo et al., 2015). Tea fraud often involves the substitution of lower-grade leaf for premium goods, false claims of geographical indication (for example, Taiwanese oolong sold under a foreign origin, Chinese green teas marketed under a protected regional name), or misrepresentation of storage age, which materially affects the price of aged teas.

Conventional authentication relies upon gas chromatography–mass spectrometry (GC–MS), high-performance liquid chromatography, near-infrared (NIR) spectroscopy, DNA-based methods, and trained sensory panels. Such techniques are accurate but are typically expensive, slow, destructive, and dependent on specialist expertise, limiting their applicability to high-throughput screening at reception, in warehouses or at ports of entry (Gliszczyńska-Świgło & Chmielewski, 2017). The e-nose has emerged over the last two