

Novel Insights into Food Flavor Chemistry and Analysis

Roberta Foligni * and Gianluca Tripodi * 

Department of Human Sciences and Promoting of the Quality of Life, San Raffaele Telematic University Rome,
Via Val Cannuta 247, 00166 Rome, Italy

* Correspondence: roberta.foligni@uniroma5.it (R.F.); gianluca.tripodi@uniroma5.it (G.T.)

Aromatic fingerprints provide essential insights into the compositional and structural characteristics of food matrices, as well as into the technological processes and treatments to which they have been subjected. In particular, the volatile compound profile associated with a given food product can be effectively exploited as a multifactorial indicator of quality attributes and shelf-life stability. Furthermore, such profiles represent a robust analytical tool for authenticity and traceability assessment [1–4], similarly to the lipid and protein profile, enabling the detection of adulteration, mislabeling, or process-induced alterations [5–8]. Beyond their analytical relevance, volatile fingerprints also constitute a key determinant of sensory perception and consumer acceptance, thereby exerting a direct influence on product marketability and associated economic value [9–11]. Chemical characterization of volatile fractions, when integrated with both conventional analytical methodologies (e.g., gas chromatography-based techniques) [12,13] and advanced instrumental approaches (e.g., high-resolution mass spectrometry and sensor-based systems) [14,15], plays a pivotal role in elucidating the effects of innovative processing technologies, alternative preservation strategies, and formulation changes [16,17]. This integrated analytical framework is particularly relevant for evaluating the impact of novel treatments, processing parameters, product development strategies, storage conditions, and the incorporation of emerging or functional ingredients [18–20]. Within this context, real-time and dynamic monitoring of volatile compound evolution has emerged as a particularly advantageous approach [21–24]. Such strategies enable continuous or time-resolved assessment of aroma-related changes, providing a more comprehensive and representative characterization of food systems throughout their entire transformation and storage lifecycle. Consequently, these methodologies support a deeper understanding of process, structure, function relationships in complex food matrices, facilitating improved control over product quality, stability, and sensory attributes [25]. Ponnampalam et al. (2025) examine how production systems, feeding strategies, and processing influence volatile organic compound (VOC) profiles, creating distinct aroma “fingerprints” in animal products. These fingerprints can serve as indicators of quality, authenticity, and traceability. The review highlights advances in analytical methods such as GC–MS, GC–IMS, and electronic noses and links specific VOCs to sensory attributes like grassy, nutty, buttery, or rancid notes that shape consumer perception and willingness to pay. The authors show that these aroma patterns reflect production and processing differences and can support regulatory claims, provenance verification, and label integrity. The volatile profile can also be an indicator of applied agricultural practices that are reflected in the fingerprint of the final product. *Antrodia cinnamomea* is a rare medicinal fungus with notable hepatoprotective, hypoglycemic, and antitumor properties. Ma et al., 2025 compared volatile profiles



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of its mycelium produced via solid-state (SAC), liquid (LAC), and dish (DAC) cultivation using electronic sensory systems (E-tongue and E-nose), GC-IMS, and multivariate statistical analyses. Distinct aroma profiles were observed among cultivation methods. GC-IMS identified 75 volatile compounds, mainly esters, alcohols, and ketones, with 41 key markers discriminating the groups via PLS-DA and OPLS-DA analyses. These results highlight cultivation-dependent metabolic differences and provide a volatile fingerprint useful for quality control, standardization, and functional food development. Nowadays, the maximum potential in the research and determination of volatile components is offered by the coupling of multiple analytical techniques. Cai et al., 2025 systematically compared the flavor profiles of three traditional Chinese sausages (Cantonese, Five-Spice, and Mala) using HS-GC-IMS, amino acid analysis, electronic sensory analysis, and sensory evaluation. Sensory evaluation showed distinct flavor profiles: Mala sausage was characterized by strong pungency and numbing sensations, Cantonese sausage by sweet and alcoholic notes, and Five-Spice sausage by a milder taste. A total of 39 volatile compounds were identified, with 2-methyl-1-butanol, 2-butanone, and butanal as the most abundant. OPLS-DA highlighted key differential compounds, including terpenes and aldehydes, as major contributors to flavor differentiation. Mala sausage also exhibited significantly higher free amino acid levels, particularly glutamic acid and proline, which strongly influenced taste perception. Overall, the results provide insights into the chemical and sensory basis of flavor variation in traditional Chinese sausages, supporting improved flavor control and product optimization in sausage production. An important step in aromatic characterization is represented by the correlation between data and consumer perception. Tripodi et al., 2025 evaluated monofloral honey from *Capparis spinosa* L. produced by *Apis mellifera sicula* in the Aeolian Islands, focusing on its volatile profile, sensory properties, and consumer acceptance. GC-MS analysis identified 59 volatile compounds, with dimethyl sulfide as the main component. Sensory evaluation revealed a distinctive profile characterized by sweet-caramel, cabbage-like, and pungent notes, which correlated with specific VOCs. Consumer testing showed lower overall preference compared to multifloral honey, although responses varied by age. Despite limited consumer acceptance, the honey's unique chemical and sensory characteristics indicate potential for niche markets and highlight its relevance for diversification in climate-resilient apiculture. A contribution to be highlighted in the formation and complexity of the generation of the final volatile profile of a food product is given by the storage conditions. Jesenko et al., 2025 investigated the effects of continuous ethanol and hexanal exposure on aroma volatile production in 'Gala' apples during six months of controlled atmosphere storage. Apples were stored at 2 kPa O₂ and 1 °C with either ethanol or hexanal (50 µg L⁻¹). Twenty-five volatile compounds were identified, with nine key contributors to aroma. Hexanal increased hexyl acetate, while ethanol enhanced 2-methylbutyl acetate and ethyl 2-methylbutanoate; both treatments promoted 1-butanol formation, particularly after two months of storage. The effects were stronger at mid-storage than after six months, suggesting a temporal decline in precursor effectiveness. Overall, ethanol and hexanal altered aroma biosynthesis pathways and improved the formation of key aroma compounds. These treatments may help preserve or enhance sensory quality in aroma-sensitive cultivars like 'Gala' during short- to medium-term storage. Comprehensive New Insights Mechanisms and Detection Methods can provide a comprehensive framework also regarding the senses and in particular the Sweet Taste Transmission. Sun et al., 2025 summarizes current knowledge on sweet taste mechanisms and detection methods, including sensory analysis, electronic tongues, and biosensors, highlighting their advantages and limitations. It also emphasizes recent advances in biosensors based on receptor–ligand recognition and nanomaterials for im-

proved sensitivity and selectivity. Finally, an integrated detection approach combining molecular sensing, data fusion, and artificial intelligence is proposed to enable more precise sweetness evaluation and support the development of healthier food systems. The role of taste has been used in varietal discrimination, specifically for evaluating whether taste alone can distinguish Chardonnay from non-Chardonnay wines. Seinform et al., 2025 show that Initial discrimination tests indicated that some Chardonnay wines could be identified based solely on taste; however, overall performance was limited compared to conditions including olfaction, confirming the dominant role of aroma in wine recognition. A second set of experiments using the Rate-All-That-Apply (RATA) method identified key taste descriptors such as fattiness, saltiness, bitterness, and acidity as contributing factors in differentiating Chardonnay from other varieties, particularly Sauvignon Blanc. Multisensory evaluation remains essential, although taste attributes still offer valuable insights into wine characterization.

In conclusion, determining and characterizing the volatile profile and combining instrumental analytical techniques with innovative technologies can provide a wealth of information about a food product. The processed data can identify a specific product, but it can also distinguish between different varieties and potential adulterations. Finally, the combination with sensory evaluation and consumer acceptance also provides the basis for marketing aspects that can enhance the final product.

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List of Contributions

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