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Honey Authentication and Adulteration Detection Techniques: Ensuring Purity in Nature's Sweetest Gift

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Abstract

Honey is a natural product highly valued for its nutritional, therapeutic, and functional properties. Its complex composition—comprising sugars, enzymes, amino acids, vitamins, minerals, and bioactive compounds—underpins its diverse health benefits. However, the growing global demand and high commercial value of honey have led to widespread adulteration, compromising its quality, authenticity, and consumer trust. This review critically examines the chemical composition of honey, key quality parameters, common adulteration practices, and advanced analytical techniques used for authentication. Emphasis is placed on modern approaches, including chromatographic, spectroscopic, isotopic, and molecular methods, as well as emerging technologies such as biosensors and artificial intelligence. Strengthening authentication strategies is essential to ensure honey purity, protect consumers, maintain market integrity, and promote sustainable apiculture.

Keywords: Adulteration detection; chromatography; honey authentication; quality assessment; spectroscopy

1. Introduction

Honey, often regarded as nature's sweetest gift, has been treasured by human civilizations for thousands of years as a natural sweetener, source of nutrition, and traditional medicine. According to the Codex Alimentarius Commission, honey is defined as a natural substance produced by honey bees from plant nectar, plant secretions, or excretions of plant-sucking insects, which are collected, transformed, dehydrated, and stored in honeycombs to mature (Codex Standard, 2001). This intricate natural process imparts honey with its distinctive flavor, aroma, and rich biochemical coAmposition. Beyond its sweetness, honey is valued for its nutritional and therapeutic properties In addition to carbohydrates, it contains enzymes, amino acids, vitamins, minerals, phenolic compounds, and other bioactive substances that contribute to its antioxidant, antimicrobial, and anti-inflammatory activities (Siddiqui et al., 2017; Geana & Ciucure, 2020; Zhang, Qing, et al., 2021; Zhang, Wang, et al., 2021). Emerging evidence further highlights its potential roles in wound healing, anticancer activity, and antiviral applications (Geana & Ciucure, 2020; Tsagkaris et al., 2021).

In recent years, the growing consumer preference for natural and functional foods has significantly increased the global demand for honey. However, its high economic value has also made it one of the most frequently adulterated food products worldwide. Common fraudulent practices include the addition of low-cost sugar syrups, blending with inferior-quality honey, and mislabeling of botanical or geographical origin for economic gain (Zábrodská & Vorlová, 2015). Such practices not only reduce the nutritional and medicinal quality of honey but also erode consumer trust and negatively impact the livelihoods of genuine beekeepers (Geana & Ciucure, 2020).

Ensuring the authenticity and purity of honey has therefore become a major challenge for the global honey industry. Conventional quality standards and analytical approaches are often inadequate for detecting sophisticated adulteration. In response, advanced techniques involving physicochemical analysis, chromatography, spectroscopy, isotopic methods, and molecular tools have been developed to improve accuracy in authentication and origin verification (Soares et al., 2017; Wu et al., 2017; Naila et al., 2018; Tsagkaris et al., 2021).

Against this backdrop, this article presents an overview of honey adulteration, its impact on quality and authenticity, and the modern analytical techniques used for its detection. It also highlights recent advancements and emerging trends aimed at ensuring the purity, safety, and market integrity of honey.

2. Chemical Composition of Honey

Honey is a complex natural substance composed mainly of carbohydrates and water, along with minor constituents such as proteins, amino acids, vitamins, minerals, enzymes, and bioactive compounds. Its composition varies with floral source, geographical origin, and environmental conditions. Carbohydrates constitute the major fraction, with fructose and glucose as the dominant sugars responsible for sweetness and energy value. In addition, small amounts of disaccharides and oligosaccharides—including sucrose, maltose, trehalose, and turanose—contribute to its physicochemical characteristics such as flavour and viscosity. It also contains trace levels of proteins and free amino acids, which are influenced by nectar source. Common amino acids include methionine, arginine, lysine, tryptophan, and alanine. Vitamins, primarily B-complex and vitamin C, occur in small quantities and vary among floral types. Furthermore, phenolic compounds and flavonoids present in honey contribute to its antioxidant properties. Minerals such as potassium, calcium, magnesium, sodium, iron, and zinc are also present, with their levels depending on botanical and environmental factors.

Overall, the diverse composition of honey underpins its nutritional and functional properties (Raptopoulou et al., 2020; Pătruică et al, 2022).

3. Criteria for Assessing Honey Quality

Honey quality is evaluated using a set of physicochemical and enzymatic parameters that reflect its purity, freshness, and processing conditions. Key indicators such as moisture content, acidity, electrical conductivity, hydroxymethylfurfural (HMF), diastase activity, and sugar composition are widely used to assess its overall quality. Since no single parameter is sufficient on its own, a combined evaluation provides a more reliable understanding of honey integrity and helps identify possible deterioration or adulteration, as summarized in Table 1 (Raptopoulou et al., 2020).

Table 1. Key Parameters for Assessing Honey Quality

Parameter	Description	Significance in Quality Assessment	Indicators of Adulteration / Poor Quality
Moisture Content & Acidity	Measures water content and organic acid levels in honey	Determines shelf life, stability, and susceptibility to fermentation	High moisture may indicate dilution (water addition); abnormal acidity suggests spoilage or improper handling
Electrical Conductivity	Reflects mineral and ion content	Useful for differentiating honey types (honeydew vs blossom)	Unusual values may indicate mislabeling or altered composition
Hydroxymethylfurfural (HMF)	Compound formed during sugar degradation (heat/storage)	Indicator of freshness and thermal history	High HMF suggests overheating, prolonged storage, or addition of sugar syrups
Diastase Activity	Enzyme activity related to starch breakdown	Reflects freshness and enzymatic integrity	Low activity may indicate overheating, prolonged storage, or artificial feeding practices
Sugar Composition	Proportion of fructose, glucose, and minor sugars	Defines natural honey profile and quality	Presence of unusual sugars (mannose, lactose, galactose, xylose, arabinose, rhamnose) or abnormal ratios indicates adulteration

4. Honey Authenticity and Related Issues

Honey authenticity has become a critical concern due to the increasing complexity of production, processing, and market practices. Despite established international standards, various factors across the production chain can compromise the natural integrity of honey (Codex Standard, 2001; Wu et al., 2017; Tsagkaris et al., 2021). These issues arise not only from intentional manipulation but also from beekeeping practices, environmental influences, and post-harvest handling (Siddiqui et al., 2017; Geana & Ciucure, 2020).

Broadly, challenges related to honey authenticity can be categorized into direct adulteration and indirect adulteration (Soares et al., 2017; Nisbet et al., 2018), as illustrated in Fig. 1. Understanding these categories is essential for identifying sources of quality deterioration and improving detection and control strategies.

4.1. Direct Methods of Honey Adulteration

Direct adulteration involves the intentional addition of foreign substances to honey to increase volume or mimic desirable characteristics. Common adulterants include water, sucrose, invert sugar, caramel, starch, dextrin, and additives such as carboxymethyl cellulose (CMC). These substances alter honey’s natural properties—diluted honey becomes prone to fermentation, while added sugars or caramel can change taste, color, and transparency. Some of these changes can be detected through sensory evaluation or standard quality tests.

However, modern adulteration practices have become increasingly sophisticated. Adulterants such as high-fructose corn syrup (HFCS), corn syrup, maltose syrup, sucrose syrup, and rice syrup closely resemble the natural sugar composition of honey, making detection more difficult (Wang et al., 2015; Li et al., 2017; Qu et al., 2019; Huang et al., 2021; Akyıldız et al., 2022; Cagliani et al., 2022). Among these, HFCS is widely used due to its similar fructose-to-glucose ratio to that of natural honey. To further imitate authentic honey, adulterated products may also contain artificial colors and flavoring agents (Wu et al., 2017).

Another form of direct adulteration is the blending of high-value honey, such as monofloral honey, with lower-quality varieties. Monofloral honey, derived predominantly from a single floral source, commands a higher market price due to its distinctive flavor and therapeutic properties (Soares et al., 2017; Machado et al., 2020; Geana & Ciucure, 2020). Fraudulent practices such as mixing, decolorizing cheaper honey (e.g., rape honey) to resemble premium types like acacia honey, and mislabeling geographical or botanical origin are increasingly reported worldwide (Se et al., 2019; Yayinie et al., 2021; Rodopoulou et al., 2022).

4.2. Indirect Methods of Honey Adulteration

Indirect adulteration occurs through improper beekeeping, harvesting, and processing practices rather than direct addition of substances. One common method is feeding honey bee colonies with sugar syrups during nectar flow periods, which alters the natural sugar composition of honey (Nisbet et al., 2018). Such practices introduce artificial sugars into honey through biological processes, making detection more complex.

Environmental factors such as climate change, reduced flowering periods, and declining nectar sources have also encouraged such practices to maintain production levels. Analytical techniques like carbon isotope ratio analysis and advanced mass spectrometry can help detect such adulteration by identifying unique chemical markers (Guler et al., 2014; Akyıldız et al., 2022).

Another important issue is the harvesting of unripe honey. Naturally, bees require about 7–15 days toconvert nectar into fully matured honey. Prematurely harvested honey contains higher moisture (above 20%), lower density, and incomplete sugar conversion, making it more susceptible to fermentation and spoilage (Codex Standard, 2001; Siddiqui et al., 2017). Parameters such as moisture content, sucrose levels, and proline content are commonly used to assess honey maturity and quality (Geana & Ciucure, 2020).

Post-harvest handling also plays a crucial role. Practices such as excessive heating, improper storage, and prolonged shelf life can degrade honey quality by reducing enzyme activity and bioactive compounds. The formation of 5-hydroxymethylfurfural (HMF), a compound produced during heating and storage, serves as a key indicator of honey freshness and quality (da Silva et al., 2016; Geana & Ciucure, 2020).

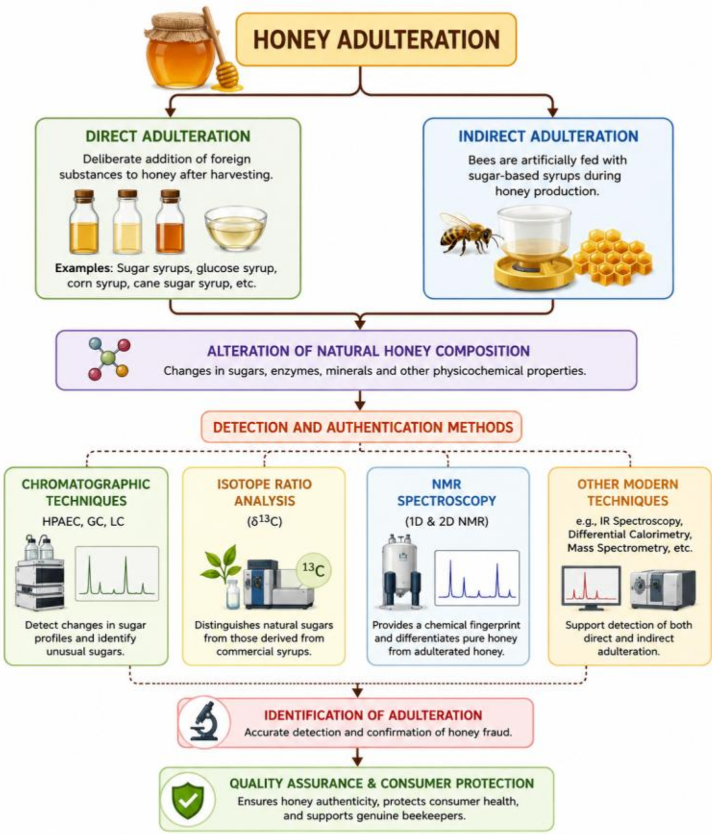

Fig 1. Overview of Honey Adulteration and Detection Methods

5. Methods for Honey Authenticity Verification

The authentication of honey has become increasingly important due to the growing sophistication of adulteration practices and the intrinsic variability of its composition. Differences in botanical origin, geographical conditions, and processing factors contribute to natural heterogeneity, making it difficult to distinguish genuine honey from adulterated products. Consequently, reliable and sensitive analytical methods are essential to ensure product integrity, prevent economic fraud, and support regulatory compliance. A broad range of analytical strategies has been developed, including conventional quality assessments, advanced instrumental techniques, and chemometric tools, which together enable accurate detection of adulteration and verification of origin, as summarized in Table 2.

5.1. Conventional Methods and Quality Standards

Traditional evaluation relies on physicochemical and sensory parameters established by international standards such as Codex Alimentarius and the EU Honey Directive (Codex Standard, 2001; Directive, 2001; Tsagkaris et al., 2021). These include moisture content, sugar profile, electrical conductivity, acidity, ash content, enzyme activity, and hydroxymethylfurfural (HMF) levels. Sensory attributes such as color, aroma, taste, and viscosity provide preliminary quality indicators (Price et al., 2019). Melissopalynological analysis is commonly used to determine floral origin (Juan-Borrás et al., 2015), although its reliability may be affected by environmental variability and possible manipulation (Addi & Bareke, 2021). While these methods are cost-effective and widely used, they have limited capability in detecting sophisticated adulteration.

5.2. Advanced Instrumental and Chemometric Approaches

To improve detection accuracy, advanced analytical techniques are employed for detailed characterization of honey composition, including sugars, phenolics, volatiles, and isotopic signatures (Kato et al., 2014; Osés et al., 2020).

5.2.1. Chromatographic and Isotopic Techniques

Chromatographic methods such as GC, LC, and HPAEC are widely used for sugar profiling and adulterant detection, while GC–MS enables analysis of volatile compounds associated with floral origin. Stable isotope ratio analysis (e.g., $\delta 13C$) is particularly effective in identifying adulteration with C4 plant sugars.

5.2.2. Spectroscopic Techniques

Techniques such as FTIR, NIR, Raman spectroscopy, and NMR offer rapid and non-destructive analysis by generating chemical fingerprints of honey samples. Among these, NMR provides high-resolution profiling and simultaneous detection of multiple constituents.

5.2.3. Bioanalytical and Sensor-Based Techniques

DNA-based methods (PCR, DNA barcoding, metabarcoding) allow precise identification of botanical origin through genetic material analysis (Soares et al., 2018). Sensor-based systems such as electronic nose and electronic tongue enable rapid classification based on aroma and taste patterns (Yin et al., 2021).

5.2.4. Chemometric Integration

Chemometric tools, including PCA, PLS, and SVM, are applied to interpret complex datasets, enabling classification and prediction of authenticity (Silva et al., 2021; Yong et al., 2022). The integration of these tools with analytical techniques enhances detection efficiency and reliability.

5.3. High-Throughput Techniques and Sample Preparation

Effective sample preparation is essential to isolate minor bioactive compounds from the sugar-rich matrix of honey. Common techniques include LLE, SPE, CC, MAE, and UAE (Medina et al., 2019). Recent developments focus on efficient and environmentally friendly methods such as SPME, DLLME, and ATPS, which improve sensitivity while reducing solvent usage (Enriquez-Ochoa et al., 2020). SPME coupled with GC–MS is widely used for volatile analysis, whereas column chromatography is effective for compound isolation (Karabagias et al., 2022).

5.4. Authentication of Botanical and Geographical Origin

The origin of honey significantly influences its physicochemical and sensory properties. Modern authentication approaches rely on chemical and biological markers such as phenolic compounds, volatile compounds, amino acids, mineral composition, and DNA. These markers serve as distinctive fingerprints for determining floral and geographical sources (Juan-Borrás et al., 2015). Mineral composition reflects environmental conditions, while phenolic and volatile compounds are closely associated with specific plant sources. DNA-based techniques further enhance accuracy by directly identifying plant species visited by honey bees.

5.5. Emerging Technologies and Future Trends

Recent advances include biosensors, artificial intelligence-based models, and portable analytical devices that enable rapid and on-site authentication. The integration of machine learning with analytical techniques is expected to further enhance accuracy and enable automated detection of adulteration across the supply chain.

Table 2: Instrumental Techniques for Honey Authentication

Analytical Category	Methods/ Tools	Principle	Applications in Honey Authentication	Advantages	Limitations	Key References
Chromatographic & Hyphenated Techniques	GC, HPLC, UHPLC, GC–MS, LC–MS, HPLC-DAD, HPLC-RID, PAD	Separation based on physicochemical interactions and volatility	Sugar profiling; phenolics and volatiles analysis; detection of adulterants; origin assessment	High sensitivity; accurate compound identification	High operational cost; time-intensive; requires skilled personnel	Machado et al., 2020; Zhang et al., 2021a; Zhang et al., 2021b; Tosun & Keleş, 2021; Akyıldız et al., 2022
Spectroscopic Techniques	UV–Vis, NIR, MIR, FTIR, Raman, Fluorescence, NMR	Interaction of electromagnetic radiation with molecular structures producing spectral signatures	Rapid screening; classification by botanical and geographical origin	Fast; non-destructive; minimal sample preparation	Requires chemometric modeling; high cost (NMR)	He et al., 2020; Pauliuc et al., 2021; de Souza et al., 2021
Elemental Techniques	ICP-MS, ICP-OES	Multi-element detection via emission or mass spectra	Mineral profiling; geographical origin discrimination	High precision; simultaneous multi-element detection	Expensive instrumentation; extensive sample preparation	Geană et al., 2020; Magdas et al., 2021
Isotopic Techniques	Stable isotope ratio analysis (δ13C,	Measurement of isotopic signatures linked to	Detection of C3/C4 sugar adulteration; origin	Highly reliable; internationally	High cost; requires specialized expertise	Geană et al., 2020; Magdas

	δ2H, δ18O)	plant metabolism and environment	verification	recognized		et al., 2021
Bioanalytical Techniques	PCR, DNA barcoding, metabarcoding, HRM, NGS	DNA-based identification of plant and bee origin	Floral source authentication; mislabeling detection	High specificity; strong traceability	DNA degradation; advanced laboratory requirements	Soares et al., 2018; Moškrič et al., 2021
Electrochemical & Sensor-Based Methods	E-nose, E-tongue, E-eye	Sensor arrays mimicking sensory perception patterns	Rapid classification; screening for adulteration	Portable; cost-effective; rapid analysis	Lower accuracy compared to advanced instrumental methods	Yin et al., 2021
Integrated & Emerging Approaches	Data fusion, metabolomics, MRJP profiling	Integration of multi-analytical datasets for holistic profiling	Comprehensive authentication; improved discrimination and classification	High robustness; enhanced accuracy	Complex data interpretation; requires computational expertise	Soares et al., 2017; Akyıldız et al., 2022

The integration of advanced analytical techniques with chemometric tools, as outlined in Table 2, significantly enhances the reliability and accuracy of honey authentication, making multi-technique approaches the most effective strategy.

6. Quality Assurance in Honey Authentication

Ensuring the reliability of honey authentication requires the application of validated and standardized analytical protocols. Robust quality assurance frameworks are essential to guarantee the accuracy, precision, and reproducibility of analytical results, particularly in the detection of adulteration and verification of origin. International standards, such as ISO/IEC 17025, provide a comprehensive foundation for laboratory competence, method validation, and quality control in honey analysis. Critical aspects of quality assurance include appropriate sampling strategies, as well as controlled handling, transportation, and storage conditions to preserve sample integrity and prevent compositional alterations. The use of certified reference materials and participation in proficiency testing schemes further enhance the credibility and comparability of analytical results across laboratories. Method validation involves the systematic evaluation of key performance characteristics, including accuracy, precision, sensitivity, selectivity, robustness, and limits of detection and quantification. In addition, routine quality control measures—such as calibration verification, blank analysis, and replicate testing—are necessary to ensure ongoing analytical reliability. Adherence to these quality assurance practices not only strengthens confidence in analytical findings but also supports regulatory compliance and facilitates the standardization of honey authentication methodologies at national and international **(**Raptopoulou et al., 2020**).**

7. Conclusion and Future Perspectives

The challenge of ensuring honey authenticity is no longer just a scientific issue—it is a matter of consumer trust, fair trade, and sustainability. As global demand for honey continues to rise, so does the incentive for economically motivated adulteration. This ongoing "arms race" between fraudsters and detection technologies highlights a critical gap: traditional testing approaches often react to problems rather than anticipate them.

Future progress in honey authentication will depend on shifting from single-parameter testing to holistic profiling. Instead of relying on a few chemical indicators, the next generation of methods will focus on understanding honey as a complete biological system—capturing its chemical complexity, ecological origin, and processing history in a unified manner.

One promising pathway is the identification of intrinsic authenticity signatures—naturally occurring compounds that are difficult to replicate artificially. These include subtle combinations of metabolites, trace compounds, and bee-derived substances that together form a unique "fingerprint" of genuine honey. Such approaches reduce dependence on detecting specific adulterants and instead focus on confirming authenticity itself.

Another major advancement lies in the integration of multi-analytical platforms with intelligent data analysis. By combining outputs from chromatography, spectroscopy, and molecular techniques, and interpreting them through machine learning models, researchers can achieve more robust and reliable authentication. This shift toward data-driven science will allow faster detection, improved accuracy, and adaptability to emerging adulteration strategies.

Equally important is the move toward practical and decentralized testing solutions. Portable devices, rapid diagnostic kits, and sensor-based technologies are expected to transform how honey is monitored across the supply chain. From beekeepers and processors to regulatory agencies, stakeholders will increasingly have access to tools that enable real-time quality assessment rather than relying solely on laboratory-based analysis.

Looking ahead, collaboration will play a key role. Stronger links between researchers, regulatory bodies, and industry stakeholders are essential to establish standardized databases, validate new techniques, and ensure global harmonization of authenticity criteria.

In essence, the future of honey authentication lies in combining scientific innovation, technological accessibility, and regulatory cooperation. By embracing these advancements, it will be possible not only to combat adulteration more effectively but also to preserve the integrity, value, and reputation of one of nature's most remarkable foods.

References:

Addi, A., & Bareke, T. (2021). Botanical origin and characterization of monofloral honeys in Southwestern forest of Ethiopia. *Food Science & Nutrition*, *9*(9), 4998-5005.

Akyıldız, İ. E., Uzunöner, D., Raday, S., Acar, S., Erdem, Ö., & Damarlı, E. (2022). Identification of the rice syrup adulterated honey by introducing a candidate marker compound for Brown rice syrups. *Lwt*, *154*, 112618.

Cagliani, L. R., Maestri, G., & Consonni, R. (2022). Detection and evaluation of saccharide adulteration in Italian honey by NMR spectroscopy. *Food Control*, *133*, 108574.

Codex Standard, (2001). Revised codex standard for honey, 12-1981, Rev. 1 (1987), Rev. 2 (2001). In (Vol. 12, pp. 1-7).

Da Silva, P. M., Gauche, C., Gonzaga, L. V., Costa, A. C. O., & Fett, R. (2016). Honey: Chemical composition, stability and authenticity. *Food chemistry*, *196*, 309-323.

de Souza, R. R., de Sousa Fernandes, D. D., & Diniz, P. H. G. D. (2021). Honey authentication in terms of its adulteration with sugar syrups using UV–Vis spectroscopy and one-class classifiers. *Food chemistry*, *365*, 130467.

Directive, Council 2001/110/EC (2001). Council Directive of 20 December relating to honey 2001/110/EC. In: Official Journal of the European Communities. https://wipolex.wipo.int/en/text/236319.

Enriquez-Ochoa, D., Sánchez-Trasviña, C., Hernández-Sedas, B., Mayolo-Deloisa, K., Zavala, J., Rito-Palomares, M., & Valdez-García, J. E. (2020). Aqueous two-phase extraction of pshenolic compounds from Sedum dendroideum with antioxidant activity and anti-proliferative properties against breast cancer cells. *Separation and Purification Technology*, *251*, 117341.

Geana, E. I., & Ciucure, C. T. (2020). Establishing authenticity of honey via comprehensive Romanian honey analysis. *Food chemistry*, *306*, 125595.

Geană, E. I., Ciucure, C. T., Costinel, D., & Ionete, R. E. (2020). Evaluation of honey in terms of quality and authenticity based on the general physicochemical pattern, major sugar composition and δ13C signature. *Food Control*, *109*, 106919.

Geană, E. I., Ciucure, C. T., Costinel, D., & Ionete, R. E. (2020). Evaluation of honey in terms of quality and authenticity based on the general physicochemical pattern, major sugar composition and δ13C signature. *Food Control*, *109*, 106919.

Guler, A., Kocaokutgen, H., Garipoglu, A. V., Onder, H., Ekinci, D., & Biyik, S. (2014). Detection of adulterated honey produced by honeybee (Apis mellifera L.) colonies fed with different levels of commercial industrial sugar (C3 and C4 plants) syrups by the carbon isotope ratio analysis. *Food Chemistry*, *155*, 155-160.

He, C., Liu, Y., Liu, H., Zheng, X., Shen, G., & Feng, J. (2020). Compositional identification and authentication of Chinese honeys by 1H NMR combined with multivariate analysis. *Food Research International*, *130*, 108936.

Huang, T. K., Chuang, M. C., Kung, Y., & Hsieh, B. C. (2021). Impedimetric sensing of honey adulterated with high fructose corn syrup. *Food Control*, *130*, 108326.

Juan-Borrás, M., Periche, A., Domenech, E., & Escriche, I. (2015). Correlation between methyl anthranilate level and percentage of pollen in Spanish citrus honey. *International Journal of Food Science and Technology*, *50*(7), 1690-1696.

Karabagias, I. K., Karabagias, V. K., Nayik, G. A., Gatzias, I., & Badeka, A. V. (2022). A targeted chemometric evaluation of the volatile compounds of Quercus ilex honey in relation to its provenance. *Lwt*, *154*, 112588.

Kato, Y., Araki, Y., Juri, M., Fujinaka, R., Ishisaka, A., Kitamoto, N., ... & Takimoto, Y. (2014). Immunochemical authentication of manuka honey using a monoclonal antibody specific to a glycoside of methyl syringate. *Journal of agricultural and food chemistry*, *62*(44), 10672-10678.

Li, S., Zhang, X., Shan, Y., Su, D., Ma, Q., Wen, R., & Li, J. (2017). Qualitative and quantitative detection of honey adulterated with high-fructose corn syrup and maltose syrup by using near-infrared spectroscopy. *Food chemistry*, *218*, 231-236.

Machado, A. M., Miguel, M. G., Vilas-Boas, M., & Figueiredo, A. C. (2020). Honey volatiles as a fingerprint for botanical origin—a review on their occurrence on monofloral honeys. *Molecules*, *25*(2), 374.

Magdas, D. A., Guyon, F., Puscas, R., Vigouroux, A., Gaillard, L., Dehelean, A., ... & Cristea, G. (2021). Applications of emerging stable isotopes and elemental markers for geographical and varietal recognition of Romanian and French honeys. *Food Chemistry*, *334*, 127599.

Medina, S., Perestrelo, R., Silva, P., Pereira, J. A., & Câmara, J. S. (2019). Current trends and recent advances on food authenticity technologies and chemometric approaches. *Trends in Food Science & Technology*, *85*, 163-176.

Moškrič, A., Mole, K., & Prešern, J. (2021). EPIC markers of the genus Apis as diagnostic tools for detection of honey fraud. *Food control*, *121*, 107634.

Naila, A., Flint, S. H., Sulaiman, A. Z., Ajit, A., & Weeds, Z. (2018). Classical and novel approaches to the analysis of honey and detection of adulterants. *Food Control*, *90*, 152-165.

Nisbet, C., Kazak, F., & Ardalı, Y. (2018). Determination of quality criteria that allow differentiation between honey adulterated with sugar and pure honey. *Biological trace element research*, *186*(1), 288-293.

Osés, S. M., Nieto, S., Rodrigo, S., Pérez, S., Rojo, S., Sancho, M. T., & Fernández-Muiño, M. Á. (2020). Authentication of strawberry tree (Arbutus unedo L.) honeys from southern Europe based on compositional parameters and biological activities. *Food Bioscience*, *38*, 100768.

Pătruică, S., Alexa, E., Obiștioiu, D., Cocan, I., Radulov, I., Berbecea, A., ... & Moraru, D. (2022). Chemical composition, antioxidant and antimicrobial activity of some types of honey from Banat region, Romania. *Molecules*, *27*(13), 4179.

Pauliuc, D., Ciursă, P., Ropciuc, S., Dranca, F., & Oroian, M. (2021). Physicochemical parameters prediction and authentication of different monofloral honeys based on FTIR spectra. *Journal of Food Composition and Analysis*, *102*, 104021.

Price, E. J., Tang, R., El Kadri, H., & Gkatzionis, K. (2019). Sensory analysis of honey using flash profile: A cross-cultural comparison of Greek and Chinese panels. *Journal of Sensory Studies*, *34*(3), e12494.

Qu, L., Jiang, Y., Huang, X., Cui, M., Ning, F., Liu, T., ... & Luo, L. (2019). High-throughput monitoring of multiclass syrup adulterants in honey based on the oligosaccharide and polysaccharide profiles by MALDI mass spectrometry. *Journal of agricultural and food chemistry*, *67*(40), 11256-11261.

Raptopoulou, K. G., Pasias, I. N., & Proestos, C. (2020). Recent advances in analytical techniques for the determination of authenticity and adulteration of honey and its products. *Recent Advances in Analytical Techniques: Volume 4*, 125-145.

Rodopoulou, M. A., Tananaki, C., Kanelis, D., Liolios, V., Dimou, M., & Thrasyvoulou, A. (2022). A chemometric approach for the differentiation of 15 monofloral honeys based on physicochemical parameters. *Journal of the Science of Food and Agriculture*, *102*(1), 139-146.

Se, K. W., Wahab, R. A., Yaacob, S. N. S., & Ghoshal, S. K. (2019). Detection techniques for adulterants in honey: Challenges and recent trends. *Journal of Food Composition and Analysis*, *80*, 16-32.

Siddiqui, A. J., Musharraf, S. G., & Choudhary, M. I. (2017). Application of analytical methods in authentication and adulteration of honey. *Food chemistry*, *217*, 687-698.

Soares, S., Grazina, L., Costa, J., Amaral, J. S., Oliveira, M. B., & Mafra, I. (2018). Botanical authentication of lavender (Lavandula spp.) honey by a novel DNA-barcoding approach coupled to high resolution melting analysis. *Food control*, *86*, 367-373.

Tosun, M., & Keles, F. (2021). Investigation methods for detecting honey samples adulterated with sucrose syrup. *Journal of Food Composition and Analysis*, *101*, 103941.

Tsagkaris, A. S., Koulis, G. A., Danezis, G. P., Martakos, I., Dasenaki, M., Georgiou, C. A., & Thomaidis, N. S. (2021). Honey authenticity: Analytical techniques, state of the art and challenges. *RSC advances*, *11*(19), 11273-11294.

Wang, S., Guo, Q., Wang, L., Lin, L., Shi, H., Cao, H., & Cao, B. (2015). Detection of honey adulteration with starch syrup by high performance liquid chromatography. *Food chemistry*, *172*, 669-674.

Wu, L., Du, B., Vander Heyden, Y., Chen, L., Zhao, L., Wang, M., & Xue, X. (2017). Recent advancements in detecting sugar-based adulterants in honey–A challenge. *TrAC Trends in Analytical Chemistry*, *86*, 25-38.

Yayinie, M., Atlabachew, M., Tesfaye, A., Hilluf, W., & Reta, C. (2021). Quality authentication and geographical origin classification of honey of Amhara region, Ethiopia based on physicochemical parameters. *Arabian Journal of Chemistry*, *14*(3), 102987.

Yin, T., Yang, Z., Miao, N., Zhang, X., Li, Q., Wang, Z., ... & Lan, Y. (2021). Development of a remote electronic tongue system combined with the VMD-HT feature extraction method for honey botanical origin authentication. *Measurement*, *171*, 108555.

Yin, T., Yang, Z., Miao, N., Zhang, X., Li, Q., Wang, Z., ... & Lan, Y. (2021). Development of a remote electronic tongue system combined with the VMD-HT feature extraction method for honey botanical origin authentication. *Measurement*, *171*, 108555.

Yong, C. H., Muhammad, S. A., Nasir, F. I., Mustafa, M. Z., Ibrahim, B., Kelly, S. D., ... & Seow, E. K. (2022). Detecting adulteration of stingless bee honey using untargeted 1H NMR metabolomics with chemometrics. *Food Chemistry*, *368*, 130808.

Zábrodská, B., & Vorlová, L. (2015). Adulteration of honey and available methods for detection–a review. *Acta Veterinaria Brno*, *83*(10), 85-102.

Zhang, X. H., Qing, X. D., Mu, S. T., Wang, D., Zheng, J. J., Zhou, S. J., ... & Liu, Z. (2021). Authentication of honey of different nectar sources and antioxidant property evaluation by phenolic composition analysis with chemometrics. *Food Control*, *124*, 107900.

Zhang, X. H., Qing, X. D., Mu, S. T., Wang, D., Zheng, J. J., Zhou, S. J., ... & Liu, Z. (2021). Authentication of honey of different nectar sources and antioxidant property evaluation by phenolic composition analysis with chemometrics. *Food Control*, *124*, 107900.

Zhang, X. H., Wang, D., Guo, W. Y., Xiao, F. G., Liu, X. J., Zhang, A. L., ... & Liu, Y. (2021). Rapid identification of adulterated honey according to the targeted analysis of phenolic compounds using chemometrics. *European Food Research and Technology*, *247*(8), 1975-1985.

Zhang, X. H., Wang, D., Guo, W. Y., Xiao, F. G., Liu, X. J., Zhang, A. L., ... & Liu, Y. (2021). Rapid identification of adulterated honey according to the targeted analysis of phenolic compounds using chemometrics. *European Food Research and Technology*, *247*(8), 1975-1985.