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and scalable for real-time water contamination monitoring. Thus, this research introduces the integration of paper-based biosensors with advanced computational frameworks like TCN and explores its great potential as a transformative development to pave the way toward more sophisticated multi-sensor fusion systems in future studies.

9.4. Electrochemical Magnetic Nanoparticles and Paper-Based Biosensors for Plant Honey DNA Origin Detection and Authentication

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Food fraud remains an issue with significant environmental, health, and socio-economic impacts for consumers and the food industry alike. Honey, known for its natural sweetness, rich nutritional value, and numerous health benefits, is among the most adulterated foods found in the global market. Common fraudulent practices include mislabelling the honey's botanical origin, blending it with lower-quality honeys, processed sugars, or other substances. Moreover, as most of their beneficial properties are linked to honey's botanical origin, it is important to assure the safety and quality of the honey. Nonetheless, with the increasing number of reports on tampered or adulterated products appearing, there is a pressing need to develop an analytical tool that can quickly, affordably, and reliably ensure the quality and safety of honeys. In this study, an innovative inkjet-printed gold electrode paper-based biosensing platform coupled with gold-coated magnetic nanoparticles (MNPs) was developed to detect the genomic DNA of two plant species from which honey can be produced: *Castanea sativa* and *Erica arborea*. Analyzing public database platforms, a DNA-target probe for both *C. sativa* and *E. arborea* were selected and designed. These sensors resulted from the DNA hybridization reaction between the two complementary probes specific to both plant species in a sandwich format. Their complementary probes were modified with an amine (NH_2) group and a fluorescein isothiocyanate and cut in two to generate the enzymatic amplification of the electrochemical signal. The hybridization reaction was labeled with enzymes, enabling chronoamperometric measurement of peroxidase activity associated with the MNPs on the gold electrode surface. The developed biosensor was then successfully applied to detect *C. sativa* and *E. arborea* present in real plant samples and, hence, determine the botanic origin of the honeys. Therefore, these MNPs and paper-based biosensors are a viable and rapid tool to help authenticate the origin of honeys.

9.5. Emerging Trends in Paper-Based Electrochemical Biosensors for Healthcare Applications

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Paper-based electrochemical biosensors have emerged as a revolutionary technology in healthcare diagnostics due to their affordability, portability, ease of use, and environmental sustainability. These biosensors utilize paper as the primary material, capitalizing