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Current Developments and Future Projections in Biosensors for Agricultural and Food Safety

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Introduction

The foundation of contemporary society is the agricultural and food sectors, which require on-going development to achieve higher levels of productivity and quality. At the turn of the twenty-first century, pesticides and fertilisers introduced by contemporary industrial development have greatly increased agricultural output, but it is impossible to ignore the negative effects of their residues in food and environmental damage. The inevitable loss and quality assurance of the entire process from farm to fork should also be given top priority at the same time. In the past, we have frequently relied too heavily on laboratory-based precise detection techniques like high-performance liquid chromatography (HPLC), gas chromatography (GC), etc.1, but these techniques are always constrained by their high cost, lengthy processing times, skilled technicians, and specialised equipment. It is a biosensor [1].

The biosensor is a type of integrated sensor that combines a biological sensing component and a physicochemical transducer. It primarily entails the steps of sample preparation, analyses extraction, biological probe identification, detection signal conversion, signal analysis, and ultimately analyse detection by turning molecular interactions into a recognisable signal. 2 the ground-breaking research carried out by a team of experts between 1962 and 1969, Commercial portable glucose metres are a notable example, and a variety of biosensors for agricultural and food safety have appeared in the last ten years. These sensors' advantages primarily depend on their speed, portability, and practicality. 4 Technologies like precision agriculture, enabled by a range of biosensors, can supplement the limited usage of conventional instruments [2].

With the development of intensive agriculture, these factors can be artificially improved to some extent, and a number of commercial sensors have been developed for monitoring a variety of factors such as soil moisture, water level, soil temperature, conductivity, salinity, pH, solar radiation, CO2, and so on. Climate and environment are significant factors that affect crop yields, but these factors can be artificially improved to some extent. Biosensors therefore concentrate more on identifying pests, viruses, diseases, and environmental factors that are harmful to agricultural output. Wang and colleagues identified phytophthora cactorum using the bioelectronics nose modified with single-stranded DNA and a single-walled carbon nanotube, which enables the early identification of plant diseases. 6 In addition, Zhu and colleagues ingeniously predict that high pesticide residues will represent a serious hazard to food safety [3].

Ingeniously using Fe single-atom catalysts as signal amplifiers to achieve synergistic amplification by enhancing the interfacial catalytically reactions and simulating the enzyme-like activity, Zhu and colleagues invent a preferred photoelectrochemical sensor for the highly sensitive detection of organ phosphorus. The biosensor has a broad linear response range of 0.5-600 ng/mL with a low detection limit of 0.08 ng/mL. A thorough review of plant disease detection was the bulk of their findings favoured nucleic acid level detection. Despite the fact that there are few studies on the use of point-of-care testing(POCT). As a result, we believe that the unique detection method of the phage-based sensor is promising since it can effectively differentiate between dead and live bacteria [4].

In this context of animal poultry farming, disease diagnosis, health monitoring, disease prevention, and control are crucial. In particular, infectious diseases of livestock and wildlife pose a severe threat to human health, and biosensors are crucial as a rapid diagnostic tool. The well-known foot and mouth diseases (FMD), mastitis diseases in dairy animals, and other conditions are covered in Monika et al.9's systematic review of biosensors in animal husbandry and aquaculture. In an intriguing unique scenario, Sadeghi et al.10 used the sophisticated technology of the vocalisation detection system to identify different viral disorders. Using sound signals gathered by microphones and data collecting cards and evaluated by a neural network pattern, clostridium perfringens type A infection-related necrotizing enteritis can be identified and diagnosed [5].

Description

In addition, another review11 lists additional uses for electrochemical and optical biosensors in the detection of bacterial infections, pathogens, and antibiotic residues. It is encouraged that similar biosensors be created for common animal diseases, with a focus on the detection of radiation in imported aquatic products because nuclear waste contamination exists in some countries and regions. According to reports, around 30% of the food produced annually throughout the world is wasted, in part as a result of poor production and packing. Controlling the production environment and creating intelligent food packaging could both benefit from the use of biosensors. Fruit that has naturally ripened differs from fruit that has been artificially ripened in terms of its nutritional value, total soluble solids (TSS), titratable acidity (TA), and quality sensory attributes. Glucose biosensors can be used to measure the amount of glucose in fruits, which can then be used to determine the fruits' state of ripening and the shelf life of the fruit. 12 Didar et al. used an E. coli-specific RNA-cleaving fluorogenic DNAzyme probe that was covalently linked to the transparent cyclo-olefin polymer packaging film to monitor microbial contamination as a biosensor to ensure food safety.

The developed packaging surface is specific, stable for at least 14 days under various pH conditions (pH 3-9), and can detect E. coli in meat and apple juice at concentrations as low as 103 CFU/mL. This makes it possible to monitor microbial contamination in a variety of foods without removing samples or sensors from the packaging Furthermore, because the molecular recognition probe is capturing a change in the petrol atmosphere (CO2), biosensor-based intelligent tags may also represent a change in a critical role in the food package. There are other places you can look for more illustrative examples of things. The majority of the reported sensors were either expensive or impractical, which meant that only a small number of these sensors have currently been implemented in some specialised high-value food packaging.

Sensors play a crucial role in the entire process from farm to fork, supporting the agricultural and food supply chain. Through the wireless multi-sensor system, analysis of temperature, relative humidity, gas composition,

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vibration, and other relevant indicators can successfully ensure post-harvest quality monitoring and cold chain management of agricultural products. In order to assess the three stages of meat spoilage (fresh, mildly spoilt, and moderately or severely spoiled), Yu and colleagues17 proposed a two-member fluorescence sensor array. This method, which is notable for enabling sensitive detection of volatiles (organosulfur compounds) collected from 5 g of meat products in a brief period of time (1 min), and its application scenarios are anticipated to monitor the freshness of chicken and pork products during storage and transportation.

Conclusion

The sections above place more emphasis on agriculture's sustainability, but since agricultural products are sold and consumed directly by consumers, concerns about food safety have garnered a lot of media attention. This particular type of biosensor is also the most frequently reported and is growing at the fastest rate. Detection targets include pesticides, veterinary medications, heavy metals, diseases, poisons, genetically engineered products, and unlawful additions. In line with this, several detecting techniques are employed, such as immunoassay, functional nucleic acid (FNA), gene editing, synthetic bionic materials, etc. Although overview articles for such topics are available elsewhere21, we nonetheless feel privileged to introduce some significant studies to this subject. Magnetic nanoparticles have long been regarded as a hero of ultrasensitive detection, despite the fact that there are numerous detection techniques to achieve signal amplification.

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