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Mycotoxins Quantification in the Food System: Is there Any Contribution from Electrochemical Biosensors?

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Mycotoxins are organic compounds produced by fungi as secondary metabolites. The presence of mycotoxins in foods and feed not only affects economy but also represents a health hazard for humans and animals and constitutes a risk for international trade. Thus, adverse effects of mycotoxins have been described. Food and feed storage under high temperatures and moisture levels favors the growth of filamentous fungi responsible for the production of mycotoxins. Agricultural products, particularly a wide variety of grains in both, the field and during storage, are the main source of mycotoxin production in the food chain. Contact to mycotoxins can produce acute and chronic effects which span from death to serious injurious effects on central nervous, pulmonary, and cardiovascular systems. Mycotoxins attracted worldwide interest during last year's because of the important economic losses related to their impact on human health, animal production and both domestic and international commerce [1].

These compounds are usually found at trace levels, which make difficult their detection. Different quantification techniques have been used but actually the demand of rapid and economic techniques for mycotoxins determination in quality food control has increased significantly. An interesting proposal is the use of biosensors. Biosensors have been shown as valuable devices for the detection of many different target analytes in a wide range of matrices. Thus, reports about different sensors (enzyme sensors, electrochemical sensors, optical immunosensors, tissue biosensors, quartz crystal sensors, and surface plasmon resonance biosensors) for the determination of Mycotoxins and other small molecule neurotoxins have been published. Within a wide range of different types of biosensors, particularly, electrochemical biosensors (EB) have been studied for a long time. They use different types of transducers, mainly potentiometric, impedimetric, voltammetric and amperometric.

The development of EB directed to different analytes and matrices has shown a tremendous increase in recent years. This phenomenon can be associated with the significant progress in areas such as the nanotechnology among others that has allowed the application to chemical analysis of devices related to nanoparticles of different nature with particular properties [2].

The demand for specific, low cost, rapid, sensitive, and easy detection of biomolecules is huge. A wide variety of EB has been developed for measurements of some key metabolites, proteins, and nucleic acids. Moreover, emerging technologies of lab-on-a-chip microdevices and nanosensors (i.e., silicon and carbon nanotube field effect sensors) offer opportunities for the construction of a new generation of biosensors with much better performances [3].

Nanoparticles in particular were an extremely popular subject in biosensor research. This has led to an intensive use of these nanomaterials for the construction of EB with enhanced analytical performance with respect to other biosensor designs. Electrochemical enzyme biosensors including those using hybrid materials with carbon nanotubes (CNTs) and polymers, sol–gel matrices, and layer-by-layer architectures, have also been discussed [4]. CNTs play an important role in the performance of EB, immunosensors, and DNA biosensors. A review which discusses the use of CNTs in the construction of electrochemical sensors has been reported [5].

Microfluidic devices as immunosensing platforms have become an emergent technology in biomedical, pharmaceutical, environmental and food analysis.

Combination of the remarkable features of microfluidic platforms with those of immunoassays produces a promising tool for selective, sensitive, automatic, and pointof- care testing in real applications. The most common detection method is fluorescence, followed by electrochemistry [6]. Electrochemical immunosensors using potential pulse techniques in the detection step have also been reported [7].

DNA arrays, electronic noses and electronic tongues for the detection of fungal contaminants in feed, and biosensors and chemical sensors based on microfabricated electrode systems, antibodies and novel synthetic receptors for the detection of toxicogenic fungi and mycotoxins have been discussed [8].

Current methods of mycotoxins analysis usually include an extraction step, a cleanup step to reduce or eliminate unwanted co-extracted matrix components and a separation step with suitable specific detection. Quantitative methods of analysis for most mycotoxins use immunoaffinity clean-up with high-performance liquid chromatography (HPLC) separation in combination with UV, fluorescence or mass detection. Screening of samples contaminated with mycotoxins is frequently performed by thin layer chromatography (TLC), which yields qualitative or semi-quantitative results. Nowadays, enzyme-linked immunosorbent assays (ELISA) are often used for rapid screening. Particular emphasis on screening and rapid approaches has been described [9]. Studies were conducted to improve screening assays, highlighted by the number of new methods using a variety of formats and platforms, including optical and EB. Reviews about methods for analysis and sample preparation for the most often encountered mycotoxins in different samples, mainly in food, have been reported [10]. The exploitation of magnetic nanoparticles as immobilization carriers in flow-systems and the development of arrays have also been described. High analytical performance was achieved through these EB for the determination of mycotoxins [11]. Development of biosensors and their applications for mycotoxins analysis and development of micro/nanoarray transducer and nanoparticles and their use in the development of new rapid devices have been reported

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[12]. Electrochemical affinity biosensors for aflatoxins (AFB1, T2, HT-2, AFM1), ochratoxin A (OTA), trichotecenes (DON, FB1, FB2, NIV, ZEA) and others (citrinina, CIT; alternariol, AOH; alternariol mono methyl ether, AME), have been excellently collected in a recent review [13].

Undoubtedly, aflatoxins, ochratoxin A, trichothecenes, patulin, citrinin and ergot alkaloids are the mycotoxins that have received more attention because of its toxic properties. By far, aflatoxins, OTA, DON and ZEA are those that have been more investigated from the viewpoint of EB, of which much information is available. However, other mycotoxins such as citrinin, patulin, moniliformin, esterigmatosistin, etc., emerge as very important, on which attention should also be paid for future research based on EB for their quantification.

It can be concluded that a huge number of strategies have been studied in the last years for the purpose of developing new EB for determination of mycotoxins in different real matrices. The analytical features have shown the EB to be a very powerful and timely screening tool for the determination of mycotoxins in the field of food safety and in other areas. Particularly promising lines of research that I think should be explored and developed in the near future, for the quantification of mycotoxins by means of EB should be based on the use of aptamers ligands and phage-display methods from a peptide library with affinity for mycotoxins along with the use of nanotechnology tools, among others most exploited at present. I believe that in the coming years efforts should also be directed to transfer the results of the new proposals to the development of practical tools based on EB capable of being applied competitively to the methodologies currently used in laboratories for analysis of mycotoxins. In this sense, EB appear with high potential for mycotoxin analysis.

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