Short Communication

Convenient Detection of Food Toxicants Using Microbial Whole-Cell Biosensing

Ji-Yen Cheng*

Department of Mechanical and Mechatronic Engineering, National Taiwan Ocean University, Taiwan

***Corresponding author:** Ji-Yen Cheng, Department of Mechanical and Mechatronic Engineering, National Taiwan Ocean University, Research Center for Applied Sciences, Academia Sinica, No.2 Pei-Ning Road, Keelung, 20224, Taiwan

Short Communication

Human activities has brought tremendous and extensive impact on natural environment, increasing the chances of food contamination by e.g. heavy metals, polycyclic compounds, and antibiotics, most significantly in food such as meat and other animal-derived products, milk and eggs. Monitoring of food contaminants may be performed to support risk assessment. Currently, the most widely-used practice for food contaminants monitoring is to collect food samples and transport the samples to laboratories, where they are then analyzed by analytical chemistry techniques, such as gas Chromatography-Mass Spectroscopy (GC-MS) or High-Performance Liquid Chromatography (HPLC) [1,2]. While these analytical chemistry methodologies can generate highly accurate results, they are expensive, time-consuming and cannot be conducted on-site.

Moreover, sample preparation such as extraction and separation are tedious and requires well-trained personnel. As an alternative method for monitoring food contaminants, microbial Whole-Cell Biosensing (WCB) has emerged as a simple, portable and cost-effective solution [3,4].

WCB utilizes living cells to monitor toxicants in sample. One of the major advantages of utilizing microbial whole-cell sensing is the capability to access the bioavailability and the biological toxicity of the target chemicals. Therefore not all chemicals residing in the sample matrix could induce responses from the whole-cell sensors. For example, detection of PCB (polychlorinated biphenyl) using WCB [5] only requires sample dilution before the detection. For GC-MS or LC-MS analysis, solid phase extraction is required to remove salt ions and matrix proteins. Simple sample preparation required by WCB is especially advantageous when dealing with food samples, in which complex sample materials that do not induce toxic responses from WCB do not interfere with the analysis. For comparison, ICP-MS may also carry out elementary analysis (e.g. heavy metal ions) with water-diluted sample to avoid the interference from protein/fat in food sample. However, ICP-MS is expensive and could not analyze molecular compounds.

In recent years, our laboratory and our collaborators has been devoting to develop whole-cell biosensor and corresponding hardware system that could be used as a stand-alone and portable instrument for analyzing antibiotics in food samples, such as milk and egg [6,7].

We have developed a rapid and simple approach for sensitive detection of antibiotic residues based on luminescence emitted by live bacterial sensor strains, integrated into a CCD-based lens-free optical analyzer (LumiSense) [7]. Using ciprofloxacin as a model antibiotic, we demonstrate response times of between 20 to 80 min, and detection thresholds of 8ng/mL for milk, egg white and chicken essence, and 64ng/mL for egg yolk [6]. These values are below the minimal allowed values as defined by European Union regulations. While not intended to replace traditional analytical equipment and regulation-approved methodologies, LumiSense and similar systems, sample preparation for which involves only simple mixing, dilution and homogenization, may nevertheless provide a simple means for high-throughput food sample screening.

The portable LumiSense system is smaller, cheaper, much simpler to maintain and operate than sophisticated LC/MS systems, and provides a very effective alternative for quick and simple detection of antibiotic compounds.

The system is not limited in detecting antibiotics. The living bacterial sensor strains can be "tailored" to detect different classes of food contaminants such as heavy metals, veterinary drugs, pesticides, or global effects such as toxicity or genotoxicity. Future generations of the system may be able to provide comprehensive screening capabilities for diverse and application-specific targets of choice. Furthermore, integration with mobile technologies such as smart phone or other Wi-Fi-enabled devices, inexpensive detection systems could be widely deployed for comprehensive monitoring of food contaminants.

References

1. Chiesa LM, Nobile M, Panseri S, Biolatti B, Cannizzo FT, Pavlovic R, et al. A Liquid Chromatography–Tandem Mass Spectrometry Method for the Detection of Antimicrobial Agents from Seven Classes in Calf Milk Replacers: Validation and Application. Journal of Agricultural and Food Chemistry. 2016; 64: 2635–2640.

2. Tang Q, Yang T, Tan X, Luo J. Simultaneous Determination of Fluoroquinolone Antibiotic Residues in Milk Sample by Solid-Phase Extract−Liquidon−Tandem Chromatography Mass Spectrometry. Journal of Agricultural and Food Chemistry. 2009; 57: 4535–4539.

3. Melamed S, Naftaly S, Belkin S. Improved detection of antibiotic compounds by bacterial reporter strains achieved by manipulations of membrane permeability and efflux capacity. Applied Microbiology and Biotechnology. 2014; 98: 2267–2277.

4. van der Meer JR, Belkin S. Where microbiology meets micro engineering: design and applications of reporter bacteria. Nature Publishing Group. 2010; 8: 511–522.

5. Lewis C, Beggah S, Pook C, Guitart C, Redshaw C, van der Meer JR, et al. Novel use of a whole cell E. coli bioreporter as a urinary exposure biomarker. Environmental Science & Technology. 2009; 43: 423–428.

6. Kao WC, Belkin S, Cheng JY. Microbial biosensing of ciprofloxacin residues in food by a portable lens-free CCD-based analyzer. Analytical and Bioanalytical Chemistry. 2018; 410: 1257–1263.

7. Tsai HF, Tsai YC, Yagur-Kroll S, Palevsky N, Belkin S, Cheng JY. Water pollutant monitoring by a whole cell array through lens-free detection on CCD. Lab on a Chip. 2015; 15: 1472–1480.