



Research review paper

An overview of foodborne pathogen detection: In the perspective of biosensors

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ABSTRACT

Food safety is a global health goal and the foodborne diseases take a major crisis on health. Therefore, detection of microbial pathogens in food is the solution to the prevention and recognition of problems related to health and safety. For this reason, a comprehensive literature survey has been carried out aiming to give an overview in the field of foodborne pathogen detection. Conventional and standard bacterial detection methods such as culture and colony counting methods, immunology-based methods and polymerase chain reaction based methods, may take up to several hours or even a few days to yield an answer. Obviously this is inadequate, and recently many researchers are focusing towards the progress of rapid methods. Although new technologies like biosensors show potential approaches, further research and development is essential before biosensors become a real and reliable choice. New bio-molecular techniques for food pathogen detection are being developed to improve the biosensor characteristics such as sensitivity and selectivity, also which is rapid, reliable, effective and suitable for *in situ* analysis. This paper not only offers an overview in the area of microbial pathogen detection but it also describes the conventional methods, analytical techniques and recent developments in food pathogen detection, identification and quantification, with an emphasis on biosensors.

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Contents

1. Introduction	233
1.1. Food and health legislations	233
1.2. Emerging foodborne pathogens	233
2. Various methods towards pathogen detection	233
2.1. Culture and colony based methods	236
2.2. Immunology-based methods	237
2.3. Polymerase chain reaction (PCR)	237
3. Biosensors in foodborne pathogen detection	238
3.1. Introduction to biosensors	238
3.2. Classifications of biosensor	238
4. Bioreceptors	238
4.1. Antibody bioreceptors	239
4.2. Enzyme bioreceptors	239
4.3. Nucleic acid bioreceptors	240
4.4. Cellular bioreceptors	241
4.4.1. (i) Cellular systems	241
4.4.2. (ii) Non-enzymatic proteins	241
4.5. Biomimetic receptors	242
4.6. Bacteriophages	242
5. Transducers	242
5.1. Optical-based biosensors	242
5.1.1. Raman and Fourier transform infrared spectroscopy	243
5.1.2. Surface plasmon resonance	243

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5.1.3.	Optical fibers	244
5.1.4.	Other optical techniques	244
5.2.	Electrochemical biosensors	245
5.2.1.	Amperometric method	245
5.2.2.	Potentiometric detection	246
5.2.3.	Impedimetric detection	246
5.2.4.	Conductometric detection	246
5.3.	Mass-sensitive biosensors	247
6.	Electronic nose sensor	247
7.	Summary and outlook	248
	Acknowledgement	248
	References	248

1. Introduction

1.1. Food and health legislations

The food industry is the main party concerned with the presence of pathogenic microorganisms, where failure to detect a pathogen may lead to a dreadful effect. Although the safety of food has dramatically improved overall, progress is uneven and foodborne outbreaks from microbial contamination, chemicals and toxins are common in many countries (WHO, 2007b). International trade statistics (2007) by World Trade Organization (WTO) reported that Europe has accounted for 46% of world exports of agricultural products, where food represents 80% of agricultural exports (WTO, 2007). Trading of contaminated food between countries increases the potential for outbreaks and consequently, health risks posed by microbial pathogens in food are of major concern to all governments.

In November 2007, U.S. Food and Drug Administration (FDA) has developed a comprehensive 'Food Protection Plan', in which it has been mentioned that food must be considered as a potential vehicle for intentional contamination (FDA, Food Protection Plan, 2007). Such intentional contamination of food could result in human or animal illnesses and deaths, as well as economic losses.

It has been reported in the EU legislation on microbiological criteria for foodstuffs, that "foodstuffs should not contain microorganisms or their toxins or metabolites in quantities that present an unacceptable risk for human health", as laid down in Regulation (EC) No 2073/2005 (Regulation (EC), 2005). Recently, the World Health Assembly (WHA) established a global surveillance system for public health emergencies of international concern by adopting the International Health Regulations (IHR) on 23 May 2005 which came into force on 15 June 2007 (WHO, 2005).

All these current legislations on food and health provide an intense inspiration into the area of food pathogen detection. Therefore, a comprehensive literature survey has been carried out aiming to give an overview of the field of foodborne pathogen detection. First, some of the outbreaks caused by foodborne pathogens and the main pathogens that cause foodborne diseases are discussed. Next, the main conventional methods in pathogen detection are described, covering their strengths and weaknesses. Then the role of biosensors in the field of foodborne pathogen detection is analysed, comprising all main types. Since, the literature related to foodborne pathogens is vast; this paper reports on recent advances mainly on the detection, identification and quantification of pathogens, with an emphasis on biosensors.

1.2. Emerging foodborne pathogens

The World Health Organization (WHO) defines foodborne illnesses as diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food. Though the global incidence of foodborne disease is difficult to estimate, it has

been reported that in 2005 alone 1.8 million people died from diarrhoeal diseases and a great proportion of these cases can be attributed to contamination of food and drinking water (WHO, 2007a). In industrialized countries, the percentage of the population suffering from foodborne diseases each year has been reported to be up to 30%. For, example, the Centers for Disease Control and Prevention (CDC, 2005) estimated that around 76 million cases of foodborne diseases, resulting in 325,000 hospitalizations and 5000 deaths occur each year in the USA.

Some foodborne diseases are well recognized, but are considered emerging because they have recently become more common. Though there are various food borne pathogens that have been identified for food borne illness, *Campylobacter*, *Salmonella*, *Listeria monocytogenes*, and *Escherichia coli* O157:H7 have been generally found to be responsible for majority of food-borne outbreaks (Alocilja and Radke, 2003; Chemburu et al., 2005). For example, in Ireland, *Campylobacter* is the most important cause of sporadic cases of foodborne illness, with 1815 cases of *Campylobacter* infection reported in 2006 (42.8/100,000 population), which was over four times the number of Salmonellosis cases reported in the same year (FSAI, 2006). Also, most of the earlier and recent food products recalls are also due to these pathogens (Belson and Fahim, 2007). List of pathogenic microorganisms responsible for foodborne illness and outbreaks caused by them are given in Tables 1 and 2 respectively.

There are many methodical programs like good agricultural practices (Kay et al., 2008; Umali-Deininger and Sur, 2007), good manufacturing practices (Mucchetti et al., 2008; Umali-Deininger and Sur, 2007), hazard analysis and critical control point (HACCP) (Jin et al., 2008; Taylor, 2007) and the food code indicating approaches (Piatek and Ramaen, 2001), which can significantly reduce the pathogenic microorganisms in food. But still, the role of pathogen detection technology is vital, which is the key to the prevention and identification of problems related to health and safety. Next, the traditional methods employed for foodborne pathogen detection over the past decades to the recent year will be discussed, by highlighting their strengths and weakness.

2. Various methods towards pathogen detection

Conventional methods for the detection and identification of microbial pathogenic agents mainly rely on specific microbiological and biochemical identification. Conventional methods being used for the detection of pathogens are illustrated in Fig. 1, where the culture and colony counting methods involve counting of bacteria, immunology-based methods involve antigen-antibody interactions and the third polymerase chain reaction (PCR) method which involves DNA analysis. While these methods can be sensitive, inexpensive and give both qualitative and quantitative information of the tested microorganisms, they are greatly restricted by assay time, also initial enrichment is needed in order to detect pathogens which typically occur in low numbers in food.

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