LWT - Food Science and Technology 67 (2016) 62–66

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Recapitulating the competence of novel & rapid monitoring tools for microbial documentation in food systems

Ubaid ur Rahman [a], Tanvir Shahzad [b], Amna Sahar [a, c, *], Anum Ishaq [a], Muhammad Issa Khan [a], Tahir Zahoor [a], Sadia Aslam [a]

[a] National Institute of Food Science and Technology, Faculty of Food, Nutrition and Home Sciences, University of Agriculture Faisalabad, Pakistan
[b] Department of Environmental Sciences & Engineering, Government College University, Allama Iqbal Road, 38000 Faisalabad, Pakistan
[c] Department of Food Engineering, Faculty of Agricultural Engineering and Technology, University of Agriculture Faisalabad, Pakistan

ARTICLE INFO

Article history:
Received 13 August 2015
Received in revised form
31 October 2015
Accepted 22 November 2015
Available online 25 November 2015

Keywords:
Food microbiology
Rapid microbial detection
Spectroscopy
DNA sequencing
Microorganisms

ABSTRACT

The requirement of real-time monitoring of food products has encouraged the development of non-destructive measurement systems. This has directed the intentions of the researchers to introduce plenty of novel techniques that could be more reliable and provide rapid and comprehensive results regarding the microbial status of food products. Therefore, the traditional time-consuming and laborious methods should be replaced by some novel techniques to provide a prompt and non-invasive microbial testing of food. This article provides information about some innovative microbial investigation methods that could replace the conventional techniques that have been habitually used in food industries.

1. Introduction

Ensuring food safety and food quality through hazard analysis and critical control point (HACCP) system has been generally practiced by food industries for the provision of safe food throughout the whole food supply chain i.e. from primary producer to final consumer. HACCP system is a comprehensive approach which mainly focuses on preventive and control strategies at each stage of the entire food chain (Ropkins & Beck, 2000). But the major drawback in the implementation of this management system is that most of the industries are relying on the slow and conventional time consuming methods to determine the microbial quality of food. These cumbersome traditional techniques do not allow rapid monitoring of microbial load on raw materials. Another hindrance of these methods is that they are unable to provide real-time monitoring during the processing or on the final product (Dostalek & Branyik, 2003).

However, a wide number of traditional cultural techniques still have been practiced by the food industries for the detection of microbial contamination. Despite the importance of cultural methods for microbial identification, these methods cannot meet the fast-paced production and processing environments due to several hitches like these are laborious, less-reliable and time consuming. Additionally, the increased concern of modern consumer related to safety and nutritional status of processed foods has promoted the food industry to develop some rapid, reliable, simple and non-destructive methods for the detection and online monitoring of microbial hazards in food products (Kamruzzaman, Makino, & Oshit, 2015).

Therefore, it is obligatory to introduce some faster and non-invasive microbiological methods to assure a better and reliable control of raw materials as well as the final products in order to deliver an improved reactivity during the course of manufacturing process. Over recent years, a strenuous effort has been made to develop novel rapid techniques for the identification and estimation of microbial load in food, including automated immunoassays, spectroscopic analyses, microscopy, polymerase chain reaction (PCR) analyses and biochemical based detection methodologies like bioluminescence based enumeration methods (Johnson et al., 2014).

Despite several advancements in sampling and monitoring techniques that provide a rapid and automated identification

* Corresponding author. Department of Food Engineering, Faculty of Agricultural Engineering & Technology, University of Agriculture Faisalabad, Pakistan.
E-mail address: amnasahar@gmail.com (A. Sahar).

http://dx.doi.org/10.1016/j.lwt.2015.11.041
0023-6438/

system, some alternative analytical methods have also been investigated in order to ensure the accuracy of results in a much shorter time span. These techniques are based on computer vision systems, spectroscopic methods and molecular & DNA-based methodologies. The assertion of microbial safety is of prime importance for food processing industries because the demand and expectation of consumers for safe and high quality products have been constantly increased. Likewise, food safety legislations have been becoming more stringent day by day around the globe in order to transport the safe, nutritious and high quality products through international market (Wu & Sun, 2013).

The trend of fast, precise and objective food inspection methods continues to grow for ensuring safety and quality throughout the whole production process. Traditional microbial detection methods involve inclusive sampling procedures followed by classical microbiological analyses that are time consuming, laborious and do not offer instantaneous inferences (Gowen, Feng, Gaston, & Valdramidis, 2015). Currently, microbial detection and identification is based on three main methods which include conventional culturing of microorganisms in artificial environment, immunoassays and molecular techniques like PCR and DNA fingerprinting. Traditional plating techniques exploit phenotypic characteristics of microorganisms like their colony morphology and hemolysis, immunoassays involve antibody–antigen interactions (Moravek et al., 2006) to identify the specific microbial toxin (Chen & Ding, 2004), while PCR based analyses identify the genes which are responsible for the production of microbial toxins in food (Martinez-Blanch, Sanchez, Garay, & Aznar, 2009). These modern techniques have shown great potential to identify the microbial species and associated toxins in food systems with much reliability and accuracy in a shorter period of time. However, these modern techniques also have some limitations, particularly in terms of cost and expertise (Table 1). The aim of this review article is to highlight the competence of some modern methods for rapid and precise microbial identification.

2. Spectroscopic techniques

Several spectroscopic techniques have been investigated in order to explore their potential for rapid microbial identification. Among these techniques, the most prominent spectroscopic methods are Fourier transform infrared spectroscopy (FTIR) (Sahar, Rahman ur, Kondjoyan, Portanguen, & Dufour, 2016), hyperspectral imaging, fluorescence spectroscopy (Sahar, Boubellouta, & Dufour, 2011) and UV-visible near infrared (NIR) spectroscopies that have been explored to rapidly detect microbial contamination.

2.1. FTIR spectroscopy

Fourier transform infrared spectroscopy in mid infrared (MIR) region has been presented as a rapid and non-invasive technique in clinical applications and in food industries. Vibrational spectroscopy is capable to measure the biochemical changes within the food substrate and it can be used to exploit the information about the decomposition of the food and formation of metabolites by microorganisms (Argyri et al., 2013). FTIR spectroscopy implicates the observation of vibrations of excited molecules through infrared beam and the resultant absorbance spectrum epitomizes a fingerprint which is characteristic of any chemical or biochemical substance (Ellis, Broadhurst, Kell, Rowland, & Goodacre, 2002).

Ellis et al. (2002) used FTIR for the direct detection of microbial count on the surface of chicken breasts in 60 s. They concluded that this technique will be helpful for food industry in HACCP process for microbiological safety assessments of food during the processing and storage of foods. Ellis, Broadhurst, and Goodacre (2004) also compared the technique of FTIR with common method of microbial analysis. They directly exposed surface of beef to the FTIR and collected the measurements. They demonstrated that FTIR was significantly suitable for the rapid detection of microbial load on beef surface.

Ammor, Argyri, and Nychas (2009) conducted an experiment to exploit FTIR in combination with chemometrics for the rapid detection of meat spoilage. They measured bacterial counts, pH and sensory quality of minced beef samples at different temperatures and storage conditions and revealed that FTIR was a rapid, non-invasive and economical technique for measuring the spoilage of minced beef. Argyria, Panagoua, Tarantilis, Polysiouc, and Nychasa (2010) detected beef spoilage by employing FTIR with artificial neural networks. They stored beef fillets aerobically at different temperatures for up to 350 h and then FTIR spectra were measured directly from the surface of meat samples. The results demonstrated that FTIR had a significant potential to detect meat spoilage rapidly. Argyri et al. (2013) compared FTIR with Raman spectroscopy for the rapid prediction of meat spoilage. They stored minced meat samples aerobically as well as anaerobically at 5 °C and then these samples were directly run on both FTIR and Raman spectrophotometer. The data obtained from the study demonstrated that FTIR detected the bacterial counts more accurately as compared to the other technique. They concluded that these rapid and non-destructive techniques could be used in future for rapid detection of food spoilage in food industries.

2.2. Hyperspectral imaging technique

Over the past few years, numerous innovative sensing techniques have been developed that have shown a great potential for safety and quality inspection of food products (Valous, Mendoza, & Sun, 2010). Hyperspectral imaging (HSI) technique is one of these emerging technologies that are known to have the ability of real-time food quality monitoring. HSI uses the combination of conventional digital imaging and spectroscopy in a combined detection system. This arrangement makes it possible to acquire both spectral

Table 1
Advantages and disadvantages of rapid identification tools for microbial documentation in food matrices.

Techniques	Advantages	Disadvantages
FTIR and UV–Vis NIR spectroscopy	Fast, simple, no or less sample preparation; sensitive; non-destructive; qualitative plus quantitative analysis; no or less chemical cost involved, simultaneous identification and discrimination of bacteria	Misinterpretation of complex samples; requires standardization, high cost of instrument, rigorous data collection and expertise
PCR analysis (DNA based techniques)	Simple and intelligible; high efficiency; suitable for analyzing complex samples	Expensive; have high computational complexity
ELISA	Provides greater specificity; single cell identification; user friendly	Suffers in terms of desired sensitivity; typical detection limit of 10^4 CFU/mL; relatively expensive
Hyperspectral imaging	Provides spatial images; high reliability, fast detection, real-time monitoring	Sometimes contain unnecessary information rather than a single color image; need superior skills