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Review

Non-invasive analytical technology for the detection of contamination, adulteration, and authenticity of meat, poultry, and fish: A review

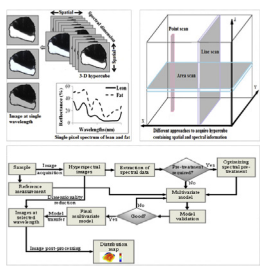
Mohammed Kamruzzaman [a,b,*], Yoshio Makino [a,**], Seiichi Oshita [a]

[a] Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan
[b] Department of Food Technology and Rural Industries, Faculty of Agricultural Engineering & Technology, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

HIGHLIGHTS

- Fundamental of hyperspectral imaging are presented briefly.
- Applications of hyperspectral imaging are reviewed.
- Application includes adulteration, contamination, and authenticity in meat, poultry and fish.
- Challenges and future trends of hyperspectral imaging technology are also discussed.

GRAPHICAL ABSTRACT



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ABSTRACT

The requirement of real-time monitoring of food products has encouraged the development of non-destructive measurement systems. Hyperspectral imaging is a rapid, reagentless, non-destructive analytical technique that integrates traditional spectroscopic and imaging techniques into one system to attain both spectral and spatial information from an object that cannot be achieved with either digital imaging or conventional spectroscopic techniques. Recently, this technique has emerged as one of the most powerful and inspiring techniques for assessing different meat species and building chemical images to show the distribution maps of constituents in a direct and easy manner. After presenting a brief description of the fundamentals of hyperspectral imaging, this paper reviews the potential applications of hyperspectral imaging for detecting the adulteration, contamination, and authenticity of meat, poultry, and fish. These applications envisage that hyperspectral imaging can be considered as a promising non-invasive analytical technique for predicting the contamination, adulteration, and authenticity of meat, poultry, and fish in a real-time mode.

Contents

* Corresponding author at: Department of Food Technology and Rural Industries, Faculty of Agricultural Engineering & Technology, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh. Tel.: +880 1849113583.
** Corresponding author. Tel.: +81 3 5841 5361
E-mail addresses: mohammed.kamruzzaman@bau.edu.bd, mohammed.kamruzaman@gmail.com (M. Kamruzzaman), amakino@mail.ecc.u-tokyo.ac.jp (Y. Makino).

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Mohammed Kamruzzaman received B.Sc. in Chemical Engineering from Bangladesh University of Engineering and Technology (BUET), MS in Food Technology from Bangladesh Agricultural University, and M.Sc. in Food Science, Technology and Nutrition from a consortium of the four European Universities (Belgium, Germany, Ireland and Portugal). He obtained Ph.D. in Biosystems Engineering under Professor Da-Wen Sun from University College Dublin (UCD), Ireland. He is an Associate Professor at the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh, Bangladesh. Currently, he is working as a JSPS post-doctoral fellow at the Department of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan. His research interests focus on hyperspectral imaging, computer vision, spectroscopy and multivariate analysis applied in determination of meat quality, safety and authenticity. His research not only has been published in prestigious international journals but has also been useful for non-destructive meat quality evaluation for the meat industry.

Seiichi Oshita is a Professor at the Department of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan. His research is focused on non-destructive hygiene monitoring of meat, postharvest handling measurements, bio-metric measurements and water containing nano-bubbles as a new technology.

Yoshio Makino is an Associate Professor at the Department of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan. His research is focused on prediction of deterioration rate of fruits and vegetables on the basis of visualized localization of enzymatic activity for respiration, non-destructive spectroscopic and hyperpsectral imaging application in food for quality monitoring and safety evaluation.

1. Introduction

Meat is an important constituent of the human diet and is consumed worldwide mainly because of its valuable nutrients such as protein, fat, iron, zinc, niacin, and vitamins B6 and B12, all of which are essential for good human health [1,2]. Traditional analytical methods are still widely used in the meat industry for detecting the contamination, adulteration, and authenticity of meat. However, these traditional destructive methods are not appropriate for a fast-paced production and processing environment because they are time consuming, laborious, and inconsistent. The consumers are concerned about contaminated and adulterated meats and the associated health risks, and this has promoted the meat industry to develop innovative and non-destructive optical sensing techniques to facilitate simple, fast, and accurate measurements.

New sensing technologies have been developed over the past decades [3],which have extraordinary capabilities for the inspection and process control of agricultural products [4]. Hyperspectral imaging is an emerging technology that has the ability of performing real-time assessment. This technique integrates conventional digital imaging and traditional spectroscopy into a single system to simultaneously acquire both spatial and spectral information from an object. Spectroscopy detects or quantifies the analyte of interest on the basis of its spectral signature, and imaging transforms this information into distribution maps for spatial visualization. Thereafter, the techniques can be used in a wide range of fields [5].

In particular, hyperspectral imaging techniques have received ample attention in the meat industry. Their applications include the examination of tenderness [6–9], pH [6], color [6,9], water holding capacity [10], chemical composition [11,12], and microbial spoilage [13] in beef; classification, grading [14,15], and prediction of quality and sensory attributes [16,17], chemical composition [18], and microbial spoilage [19–21] in pork; muscle discrimination [22], prediction of quality and sensory attributes [23,24], and chemical composition [25], and detection of authenticity [26] and adulteration [27] in lamb; detection of contaminants [28], tumors [29,30], bacterial spoilage [31–33], and freshness [34] in chicken; prediction of contaminants [35,36], composition [37,38], and freshness [39,40] in fish; and quality classification of cooked, sliced turkey ham [41].