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Short communication

A novel method for discrimination of beef and horsemeat using Raman spectroscopy

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ABSTRACT

A new approach, based on the usage of Raman spectroscopy in combination with chemometrics, was developed for the rapid determination of beef adulteration with horsemeat. The data mining process of collected Raman spectra was performed with principal component analysis (PCA). Pure fat samples, extracted from forty-nine meat beef and horsemeat samples, were analysed using the Raman spectroscopy. All meat samples were classified successfully according to their origins. The presence of different concentrations (25%, 50%, 75%, w/w) of horsemeat in beef was also differentiated using the developed model system. This study offers a rapid assay for determination of meat adulteration by discriminating beef and horsemeat with high accuracy, a short analysis time (30 s) and no requirement for time-consuming sample preparation procedures.

1. Introduction

The ongoing meat adulteration scandal in Europe brings into question the usage of horsemeat as a new adulterant in the meat industry. The determination of horse DNA in frozen beef burgers on 15 January 2013 drew attention to the issue of meat adulteration (FSA, 2013). Horsemeat is alternatively used instead of beef due to lower the cost of raising. However in most cases, horses are being slaughtered at the end of their working lives when most of the essential compounds are depleted in their meats which have no desirable organoleptic or nutritional properties (Martuzzi, Catalano, & Sussi, 2001). While horsemeat is consumed as a healthy choice of red meat in many countries, there are many countries around the world in which horsemeat is considered a forbidden food due to ethical and religious reasons.

Proper implementation of food labelling has had ever-mounting importance in recent years. Identification of meat authenticity has a place in this context, as it constitutes a significant part of a healthy human diet. The potential for large financial profits and simplicity in substituting meats as a result of their close morphological and textural similarities has exposed the industry to a wide range of adulterations with poor quality and cheaper meat alternatives (Dean, Murphy, & Downey, 2006).

Protein-based (Alamprese, Casale, Sinelli, Lanteri, & Casiraghi, 2013; Mamani-Linares, Gallo, & Alomar, 2012), DNA-based (Ali et al., 2012; Haider, Nabulsi, & Al-Safadi, 2012; Mane, Mendiratta, & Tiwari, 2012; Sakaridis, Ganopoulos, Argiriou, & Tsaftaris, 2013; Soares, Amaral, Oliveira, & Mafra, 2013; Zhang, 2013) and fat-based methods (Abbas, Fernández Pierna, Codony, von Holst, & Baeten, 2009; Rohman, Sismindari Erwanto, & Che Man, 2011) have been intensively used for the detection of meat origin. DNA- and protein-based methods such as polymerase chain reaction (PCR) and enzyme linked immunosorbent assay (ELISA) are the most specific and sensitive techniques, although the requirement for expensive equipment and technical expertise restricts the usage of these techniques; in contrast, chromatographic methods generally suffer from a low rate of reproducibility. Fat-based methods, on the other hand, offer a simpler approach and mostly employ spectroscopic techniques. Fourier-transform infrared spectroscopy and Raman spectroscopy have been come into use for this purpose in recent decade (Che Man & Mirghani, 2001; Jaswir, Mirghani, Hassan, & Said, 2003; Rohman & Che Man, 2010). The main advantages of this technique are the ability to supply information about the chemical structure of molecules without causing any alterations (Marquardt & Wold, 2004), and requiring only a small amount of the sample (Wong, Choi, Phillips, & Ma, 2009).

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Meanwhile, Raman spectroscopy has high potency for the evaluation of food quality systems during handling, processing and storage (Herrero, 2008). The combination of Raman spectroscopy with chemometric data analysis methods enables researchers to determine food adulteration in a more rapid way (Boyaci, Genis, Guven, Tamer, & Alper, 2012; Özbalci, Boyaci, Topcu, Kadılar, & Tamer, 2013).

The above mentioned situation in the meat industry obliges scientists to find simple and rapid alternatives to presently available techniques for the discrimination of beef and horsemeat. Raman spectroscopy was introduced in the present study as a new approach since there is no study available, to our knowledge, focusing on the discrimination of horsemeat, which has been fraudulently substituted or combined with beef. To fulfill this purpose, the Raman spectra of various fat samples, which were extracted from different parts of horse and beef carcasses, were collected and the data were evaluated by PCA. Successful discrimination of beef and horsemeat was established and validation studies were carried out to support the reliability of the developed model. Success of the developed method was also investigated using beef samples adulterated with horsemeat in 0%, 25%, 50%, 75% and 100% by weight.

2. Materials and methods

2.1. Chemicals

Analytical grade *n*-hexane was purchased from Riedel–de Haen (Seelze, Germany) and glass beads (1 mm in diameter) were provided by Marienfeld-Superior Co. (Lauda-Königshofen, Germany). Nitrogen gas was supplied by a local company.

2.2. Sample preparation

Meat samples were drawn out from beef and horse carcasses. Beef samples were provided from local supermarkets in Turkey while horsemeat samples were imported from local markets in Kazakhstan. To obviate the differences originating from the meat

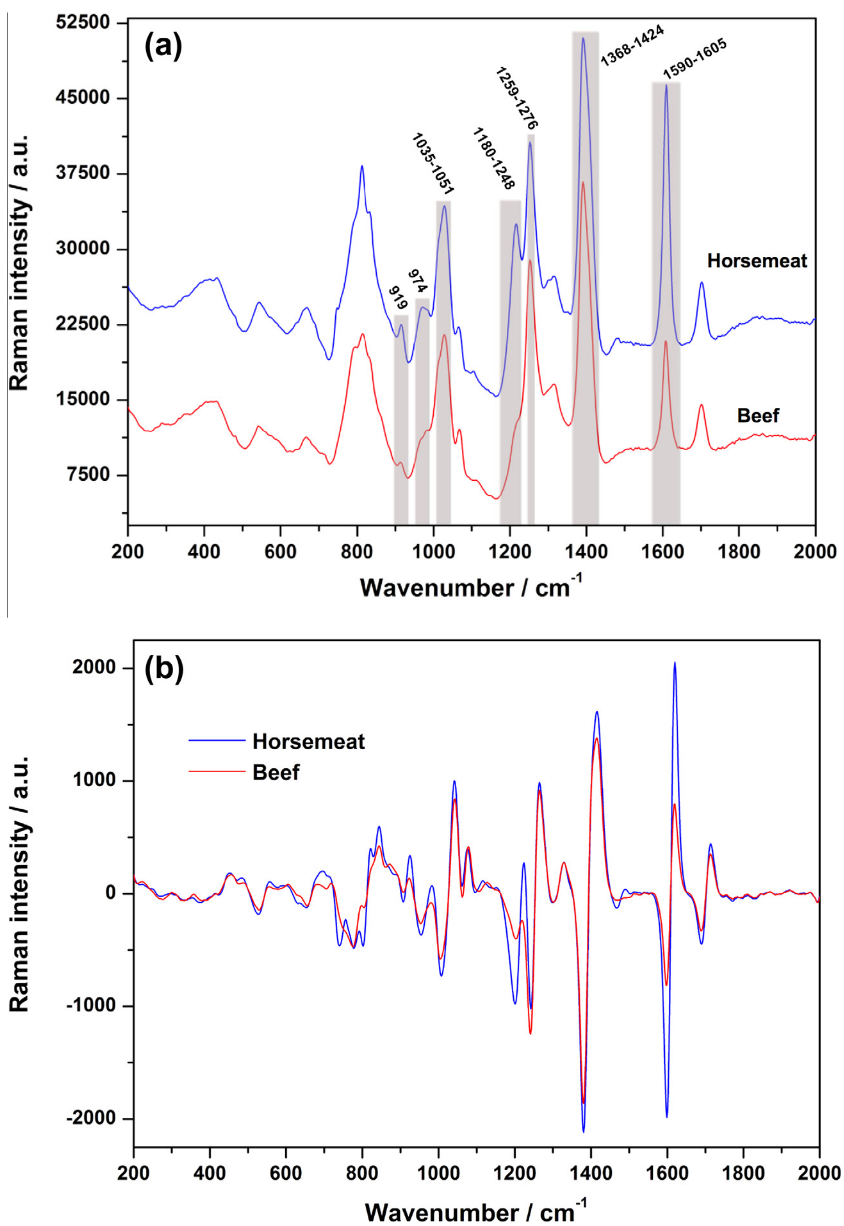

Fig. 1. Original (a) and first derivative (b) Raman spectra of horsemeat and beef samples.