Discrimination of Meat Species Using Raman Spectroscopy and PCA

Reyhan Selin Uysal[a], Tümay Temiz[a], İsmail Hakkı Boyacı[a,b*], Hasan Murat Velioğlu[c], Uğur Tamer[d]

[a] Department of Food Engineering, Faculty of Engineering, Hacettepe University, Beytepe, 06800, Ankara, Turkey

[b] Food Research Center, Hacettepe University, Beytepe, 06800 Ankara, Turkey

[c] Namık Kemal University, Vocational College, Meat and Meat Products Technology Programme, 59030, Tekirdag, Turkey

[d] Department of Analytical Chemistry, Faculty of Pharmacy, Gazi University, 06330 Ankara, Turkey

Introduction

The adulteration of meat and meat products is one of the major problems for the meat industry and trade. The adulteration is done widely due to the availability of low quality and cheap meat species. Meat adulteration can cause some crucial problems; for instance, augmenting the potential risk of foodstuffs due to the presence of intensive allergic materials or other health threatening factors. Additionally, the consumption of some meat species is banned due to religious reasons in some countries. Unfortunately, these adulterations are easy to conceal, so there is an urgent demand for the presence of reliable and rapid methods to differentiate meat species. The objective of this study was to develop a rapid and reliable method in order to discriminate the origin of the commercial meat and meat products by using of the Raman spectroscopy combined with principal component analysis (PCA) based on the spectra of the extracted fat from different meat species.

Methods

Fresh and deboned seven different meat species (cattle, sheep, goat, buffalo, pig, fish and poultry (chicken and turkey) were used in this study. Salami products of the six different meat species (cattle, sheep, goat, buffalo, chicken and pig) were produced under laboratory conditions in the unary and binary ratio. Fat samples were extracted from 111 different meat species, (cattle (N=31), sheep (N=21), goat (N=6), buffalo (N=8), pig (N=12), fish (N=14) and poultry (N=19; chicken and turkey)) and 21 salami products. Raman measurements were performed using Raman Microscopy system with a 785 nm laser source and a cooled charge coupled (CCD, at 0 °C) detector. In this study, the collected Raman data was used to create PCA models.

Procedures

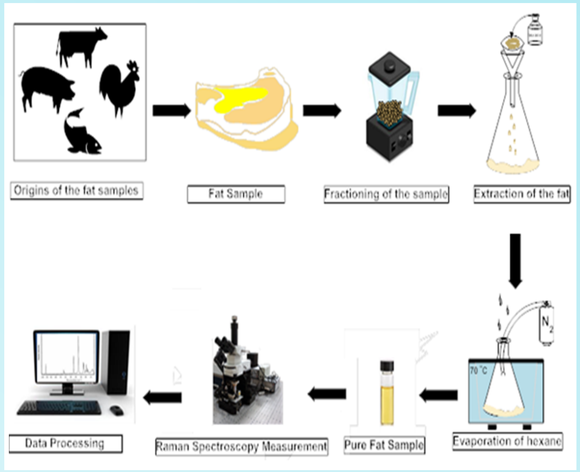


Figure 1. The schematic representation of experimental design.

Results

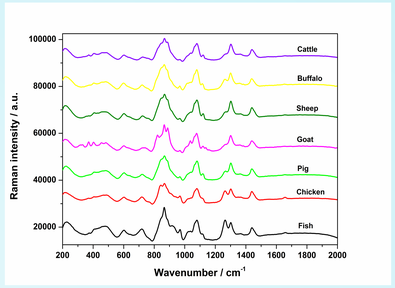


Figure 2. Raman spectra of extracted fat samples of the meat species.

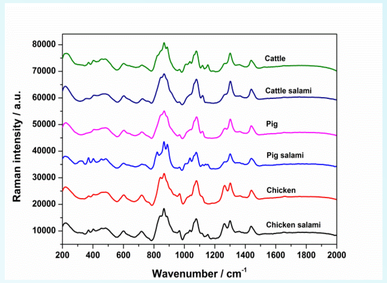
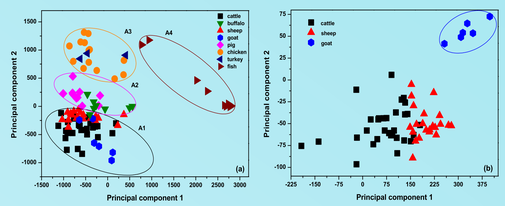


Figure 3. Raman spectra of the salami samples.

Results



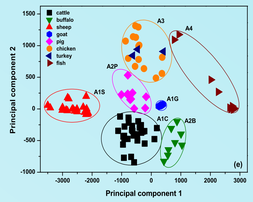


Figure 4. Stages of PCA (a) Classification of meat species; A1 (Cattle & Sheep & Goat), A2 (Buffalo & Pig), A3 (Chicken & Turkey), A4 (Fish), (b) Separation of goat samples from the cattle and sheep samples (A1 (Cattle & Sheep): A1 (C-S), A1 (Goat): A1G), (c) Separation of cattle and sheep samples (A1C, A1S), (d) Separation of pig and buffalo samples (A2 (Pig): A2P, A2 (Buffalo): A2B), (e) Denotation of the results as a combination of all stages of the analysis; A1C, A1G, A1S, A2B, A2P, A3, A4.

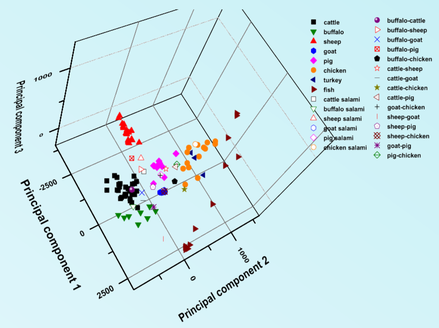


Figure 5. Three dimensional representation of PC scores plot of the extracted fat samples of meat and salami products.

Conclusion

- Successful classification of seven different meat species and their salami products.
- A simple alternative method for the differentiation of the meat species and determination of the origin of meat products.
- The effectiveness of the Raman spectroscopy combination with chemometric method was demonstrated.
- Extracted fat samples from meat is a simpler and more rapid way using for Raman measurements due to the elimination of the interference coming from the meat matrix.
- Method provides rapid and a very short time analysis.
- Hopeful methodology for the detection of the meat adulteration.

References

1. Barai BK, Nayak, R. R., Singhal, R. S., Kulkarni, P. R.,: Approaches to the detection of meat adulteration. Trends in Food Science & Technology 1992, 3:69-72.
2. Sugarman C: U. S. biologist spots counterfeit meat. 1987, 30:34.
3. Ballin NZ, Vogensen FK, Karlsson AH: Species determination - Can we detect and quantify meat adulteration? Meat science 2009, 83(2):165-174.
4. Downey G: Authentication of food and food ingredients by near infrared spectroscopy. J near Infrared Spec 1996, 4:47-61.
5. Cozzolino D, Murray I: Identification of animal meat muscles by visible and near infrared reflectance spectroscopy. Lebensm-Wiss Technol 2004, 37(4): 447-452.

*Corresponding author:
Prof. Dr. Đsmail Hakki Boyacı
Hacettepe University Department of Food Engineering Beytepe TR 06800, Ankara, TURKEY
Phone: +90 312 297 71 00 Fax: +90 312 299 21 23
E-mail: ihb@hacettepe.edu.tr